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ORIGINAL ARTICLES.

I.—Woodwardian Museum Notes. On *Calamites undulatus* (Sternb.).

By Albert C. Seward, B.A., F.G.S.,

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(PLATE IX.)

At the end of his monograph on the structure of *Calamites*, Prof. Williamson makes the following remark:[1]—"I am disposed to regard all existing specific names and definitions as worthless. They separate things that I believe to be identical, and confound others that are obviously distinct." The specimen described below affords an interesting example in support of this view.

Sternberg founded the species *undulatus* on specimens with undulating ribs, which he figured in the "Flora der Vorwelt."[2] In the "Prodrome d'une Histoire des végétaux fossiles," Brongniart includes this species in his list of *Calamites*. The same author describes *C. undulatus* in his later work,[3] but suggests, however, that it may be a variety of *Calamites Suckowii*.

Ettingshausen[4] recognizes the impossibility of separating the different species of *Calamites*, and includes *Calamites undulatus*, *C. Suckowii*, *C. æqualis*, and many others under one species, *C. communis*. Schimper[5] considers the flexuous character of the ribs and furrows of *Calamites* to be due to vertical pressure, and attaches no specific importance to it.

Dawson[6] retains the species *undulatus*, because certain specimens show the reticulate markings on the surface similar to those represented in Brongniart's figures; the undulating character of the ribs he considers may perhaps be an indication of vertical pressure.

Mr. Kidston[7] does not include the species in his catalogue; he

[1] Phil. Trans. Royal Soc. 1881, On the Organization of Fossil Plants of the Coal-measures, pt. i. *Calamites*, p. 507.

[2] Versuch einer Geognostisch-botanischen, Darstellungen der Flora der Vorwelt. vers. ii. p. 47, pl. i. fig. i. pl. xx. fig. 8.

[3] Hist. des végét. fossiles, tome i. p. 127.

[4] Die Steinkohlenflora von Radnitz in Böhmen, Abhandlungen der Kais. Königlichen Geologischen Reichsanstalt, ii. Band, 3 Abth. No. 3, p. 26.

[5] Traité de Paléontologie végétale, tome i. p. 313.

[6] Report on the Fossil Plants of the Lower Carboniferous and Millstone Grit Formations of Canada, Geol. Survey of Canada, p. 30.

[7] Catalogue of the Palæozoic Plants in the British Museum, p. 25.

regards the flexuous character of the furrows to have been imparted by pressure, any *Calamite* being liable to a bending of its furrows from the same cause.

The specimen now described and figured (Plate IX. Fig. 1. A. B.) is a pyritous sandstone cast of the medullary cavity of a *Calamite*, showing two internodes and one node. I found it in a piece of rock which had been brought to the surface in sinking a shaft at a colliery near Wigan.

Figures 1 A, and 1 B, are opposite sides of the same specimen. In Fig. 1 A, the ribs are perfectly straight and close together. No "infranodal canals" are visible on either side of the specimen. At the left-hand upper corner of Fig. 1 A, the ribs become wide and irregular: in Fig. 1 B, these characters are still further developed, the ribs and furrows now having a decidedly flexuous appearance. In Fig. 1 A, there are about eight ribs in a space of one cm., in Fig. 1 B, three occupy the same space. The length of the specimen is different on the two sides, the side with the straight ribs and furrows being 10 cm. long, and that with the flexuous ribs 9 cm. The ribs and furrows alternate at the node.

On many of the ribs there is a faint median line visible, which is in some parts rendered more conspicuous by the presence of carbonaceous matter. This difference in the breadth of the ribs on the two halves of the specimen is probably due to the original arrangement of the vascular wedges and medullary rays in the living *Calamite*. Prof. Williamson[1] has figured a transverse section of a *Calamite* in which the distance between the woody wedges varies in the two halves of the stem, the medullary rays being narrow in the one half and wide in the other half of the section. In Prof. Williamson's collection of microscopic slides, which I have had an opportunity of examining through his kindness, I have met with other specimens showing the same inequality in the size of the medullary rays on the opposite sides of the section.

In the Woodwardian Museum there is a flattened cast of the medullary cavity of a *Calamite* which shows the same characters still more clearly (Pl. IX. Fig. 2 A, B). The specimen is 18 cm. long and 6·5 cm. broad. On the side shown in Fig. 2 A, the ribs are straight and close together; on the side shown in Fig. 2 B, they are wide and flexuous. "Infranodal canals" are clearly shown on the side with wide and wavy ribs, but less distinctly on the opposite side.

The following measurements show that the internodes on the side with the wide and flexuous ribs are shorter than those with the narrow and straight ribs:—

(Plate IX.)

Fig. 2 A. (Number of ribs per cm. 35.)			Fig. 2 B. (Number of ribs per cm. 17.)		
Length of internode	i.	3·9 cm.	Length of internode	i.	3·5 cm.
,, ,,	ii.	4 cm.	,, ,,	ii.	3·7 cm.
,, ,,	iii.	4·2 cm.	,, ,,	iii.	3·0 cm.
,, ,,	iv.	3·9 cm.	,, ,,	iv.	3·7 cm.

[1] Phil. Trans. Royal Soc. 1883, On the Organization of Fossil Plants of the Coal-measures, pt. xii. pl. 33, fig. 19.

The first specimen described also showed that the shorter side was that on which the ribs were wide and flexuous. These facts suggest that the flexuous or undulating character of the ribs and furrows may have been induced by a pressure which acted on the living plant and caused it to bend; this would have the effect of widening and crumpling the ribs on the concave side of the bent plant.

II.—Elevation and Subsidence: A Suggestion.

By Professor C. Lloyd Morgan, F.G.S.,
Of University College, Bristol.

IT is unnecessary for me to remind the readers of the Geological Magazine of the evidence for elevation and subsidence. For my present purpose it is sufficient to remind them that such elevation and subsidence has been attributed (1) to lateral pressure giving rise to long geo-anticlines and geo-synclines; (2) to expansion and contraction of the underlayers resulting from a rise or a fall of temperature; and (3) to the loading and unloading of the areas of the earth's crust affected. Apparent elevation and subsidence, which we may here neglect, may be due to a rise or fall of the sea-level such as is dealt with by Prof. Hull in a recent communication to this Magazine.

(1.) There can be no doubt that the formation of long geo-clines under the influence of lateral pressure (whether produced by secular contraction, by the screwing of the earth's crust suggested by George Darwin, or otherwise) is a factor in the upheaval and depression of the land. So far as my present purpose is concerned, however, it is only necessary to point out that during the formation of geo-clines under the influences of this lateral pressure there must be a tendency to lessen the vertical pressure on the underlayers beneath a geo-anticline and to increase the pressure on the underlayers beneath a geo-syncline.

(2.) The effects of hydrothermal action on the solid underlayers of the earth's crust would seem to be of two kinds with opposite tendencies. First there is the direct effect of heat with a tendency to expansion. Mr. Mellard Reade has lately ("Origin of Mountain Ranges") insisted on the importance of this factor in the upheaval of the surface. Secondly, there are the metamorphic changes super-induced. The tendency of these is towards condensation or contraction. Which tendency predominates? I doubt if this question can be answered *à priori*. But we are taught that continued sedimentation involves a rise of the isogeotherms beneath the area in which sedimentation is taking place: and we know that there is abundant geological evidence that areas of sedimentation are also areas of subsidence. If, therefore, the changes in the solid underlayers which result from hydrothermal action take place *pari passu* with sedimentation, such evidence as we possess is in favour rather of contraction than expansion. Or if expansion does take place, its effects must be over-mastered by those of some opposing tendency or tendencies. Mr. Mellard Reade would indeed contend that the

uplift manifests itself in the mountain-building at the close of sedimentation. It is difficult, however, to understand why the effects should be so long deferred.

As a corollary from the rise of the isogeotherms beneath areas undergoing sedimentation, we have the depression of the isogeotherms beneath areas undergoing denudation. Here, therefore, cooling should produce contraction, and there should be subsidence. This is not in accordance with observation.

(3.) The intimate connection between subsidence and sedimentation on the one hand and elevation and denudation on the other hand has often been insisted on. This connection may be regarded in two ways. Many geologists maintain that denudation is consequent upon upheaval, and that continued deposition is consequent upon (or is conditioned by) continued subsidence. To others, however (and I count myself among the number), this mode of looking at the facts is not wholly satisfactory. They regard the uplift as in some way the direct result of the lightening of the load by denudation, and the subsidence as the direct result of the added load by sedimentation.

(*a*) Those who hold the latter view would seem generally to attribute the elevation and subsidence to the mere weight of the material added to or removed from a flexible crust resting upon a fluid or viscous substratum.

(*b*) Mr. O. Fisher has suggested (Proc. Camb. Phil. Soc. vol. vi. pt. 1) that water gas may be dissolved in molten rock just as carbonic anhydride may be dissolved in water. Applying Henry's law of the absorption of gases, he considers that on the pressure being relieved from that required for saturation, vesicles of gas may separate from the solvent and may coalesce and rise through the magma expanding as they reach regions of diminished pressure. From this expansion an uplift of the overlying area would result.

(*c*) Prof. Joseph Le Conte has suggested (Nature, vol. xxix. p. 213) that the principle of flotation comes into play. He assumes that the crust of continental areas is more conductive and therefore cools and thickens more rapidly than that of oceanic areas. Thus inequalities of thickness of the crust would result, and by flotation these inequalities, produced in this way on the under side next the liquid substratum, would be reproduced on the upper side next the atmosphere.

Whether such flotation would take place depends upon whether the solid produced by cooling is heavier or lighter than the liquid from which it is derived and on which it rests. Now, although there is a want of agreement as to the amount of contraction which rocks undergo on solidification and crystallization, it is well nigh universally admitted that solidification does involve such contraction and increase of density. The thickened area would therefore tend to subside rather than to be upheaved.

(*d*) It is the object of this paper to suggest other ways in which the loading and unloading of the earth's crust may indirectly bring about subsidence and elevation. I must, however, first ask and seek to answer one or two preliminary questions.

May we assume the existence of a fluid underlayer beneath the superficial crust of the earth? I think we may. From this source volcanic rock would seem to be derived; and in the plutonic rocks we seem to see the solidified crust of the once deeply-buried underlayer. Whether the fluid underlayer be continuous or in more or less isolated reservoirs we cannot say. I shall suggest in the sequel a reason why this substratum should assume the fluid or viscous state.

At what depth beneath the surface of the earth may the plutonic rocks have solidified? It is well known that Mr. Sorby from the microscopical study of the contained crystals concluded that the granites of Cornwall solidified under a pressure equivalent to that of about 50,000 feet (9½ miles) of rock, and that those of the Highlands indicate one of about 76,000 feet; while Mr. Clifton Ward suggested for the granite and granitoid rocks of Westmoreland and Cumberland a mean pressure of 44,000 feet of overload. Commenting upon these results Mr. Prestwich asks, "Are we warranted in supposing that there has been denudation to the extent of removing such enormous masses of rock as this would imply?" and Mr. A. Geikie answers, "It is not probable that any such thick overlying mass ever did cover the granite." (Prestwich, Geology, vol. i. p. 432; Geikie, Text Book, p. 297.)

What was the condition of the potential granite previous to solidification? Nearly all agree that it was rather from hydrothermal solution (at a temperature of, say, 500° C.) than from igneous fusion that the rock solidified. As was long ago pointed out by Bischof, the thinness of the granite veins which branch out into clay slate, the sharpness of the line of junction between the material of the vein and that of the country, and the slight alteration the slate has undergone, point to the mobility of the fluid and render the possibility of gradual solidification from igneous fusion out of the question. (Chem. and Phys. Geol., Paul's Translation, 1859, vol. iii. p. 52.)

What is the amount of expansion under solidification? Bischof's experiments led him to believe that the formation of granite from a liquid magma involved a contraction of 25 per cent. Delesse gave from 3 to 7 per cent. as a more probable estimate. Mr. Mallet found a smaller amount of contraction. In the solidification of plate-glass the contraction was 1·59 per cent. In the case of iron-slag the diminution of volume was 6·7 per cent. Now the sp. gr. of obsidian is from 2·4 to 2·5, while that of granite is (say) 2·65, and that of syenite (say) 2·8. This would seem to point to a diminution of volume by 6 or 8 per cent. on passing from the vitreous to the crystallized condition. Probably therefore a diminution of volume by from 6 to 10 per cent. on passing from the molten to the crystallized condition may fairly be assumed to occur.

It is well known that water expands when it passes into the condition of ice: that ice, say, at −1° C., subjected to pressure melts or is squeezed into the liquid condition: that at high pressures water may remain liquid though the temperature fall several degrees below

zero: and that on relief of pressure such liquid expands into ice. Conversely Amagat has shown (Comtes Rendus, vol. 105, p. 165), that the solidifying point of carbon tetrachloride (a substance that contracts on solidification) may be raised from $-19{\cdot}5^\circ$ C. to $+19{\cdot}5^\circ$ C. by increasing the pressure from 210 to 1160 atmospheres (approximately). I would suggest that similar changes must occur as the fluid or viscous matter in the liquid substratum is subjected to increased or diminished pressure.

Increased pressure would thus tend to squeeze the magma into the solid condition or to induce crystallisation therein. Diminished pressure would tend to allow the partially solidified or crystallized magma to expand into the fluid state.

Take the case of an area undergoing continuous sedimentation. I would suggest that the increased load must tend to squeeze the magma in the underlayers into the solid condition. But in the solid condition the rock occupies less space. Contraction must take place and the contraction is manifested at the surface as subsidence. Furthermore, without committing myself to the acceptance of the theory held by those who attribute subsidence to mere weight, I would suggest to the upholders of that theory that the added weight of the sediment above would entail on this hypothesis an added weight below—that is, if we suppose that the solidified rock adheres to the lower surface of the crust in this region.

In a region undergoing denudation, on the other hand, the lightening of the load would entail the melting of some of the solidified or crystallized magma. Such melting would be accompanied by expansion, manifesting itself at the surface by an uplift.

By the expansion of the melting underlayers tensile stress in the overlying strata would be called into play, and this would throw these strata into a state of tensile strain, thus giving origin to normal faults (to account for the formation of which tensile stress must on any theory be called into play), to the gradual gaping of mineral veins, and to dykes into which the molten matter would be injected by the expansive force.

Without denying as a factor that secular refrigeration on which Mr. Prestwich relies (Geology, vol. ii. p. 216), I would suggest that we have on this hypothesis an efficient primary cause of volcanic eruptions. In this way lava is pressed upwards towards the surface. The expansion of the contained water vapour does the rest of the business.

It is clear that the process I have here suggested would be partially checked on the one hand by the assumed rise of the isogeotherms beneath the subsiding area, such rise, primarily due to sedimentation, being increased by the latent heat rendered sensible during solidification; and on the other hand by the converse depression of the isogeotherms and rendering latent of the heat of fusion beneath areas of denudation.

In the area of subsidence lateral pressure would to some extent be brought to bear in aid of vertical pressure; for it is evident that such subsidence is equivalent to the flattening of a portion of the

(approximately) spherical crust; and such flattening involves compression.

On the view here suggested the earth's crust, instead of being eaten into from below beneath the area of sedimentation, is there relatively thickened; while beneath continental areas of denudation, instead of being thickened, it is eaten into from below. The occurrence of volcanoes on areas of elevation seems rather to lend support to the thinning of the crust in such areas, to its being rent by the stress so as to give rise to volcanic fissures, and, as in America, to fissure eruptions. Mountains on the Uinta and Park types of flexure (Geikie, Text Book, pp. 914–15) are in accordance with this hypothesis.

Concerning mountain ranges of the Jura and Alpine type, where lateral pressure has come so largely into play, I here say nothing. I believe, however, that the principle I am advocating may throw a little ray of light on that most difficult subject.

It may be objected, however, that since liquids transmit pressure equally in all directions, there is no reason why the results of that pressure should be manifested immediately beneath the loaded area. But does not this depend upon the mobility of the liquid? The less mobile the liquid, the greater the tendency for the effects of loading to be concentrated beneath the loaded area. Beneath an area of sedimentation the mobility is much decreased by incipient crystallization. Moreover, we are ignorant how far the liquid substratum is continuous, and how far in disconnected reservoirs. The objection may be more serious than I imagine. I should be glad of the opinion of physicists on this head.

There is another way in which variations of pressure due to the loading and unloading of different areas of the earth's crust may affect the liquid substratum. There can be little doubt that the water contained in the magma is above its critical temperature. Unless, therefore, it is dissolved in the molten rock, as Mr. O. Fisher has suggested, it must be in the state of compressed gas. But such a gas would expand and contract under variations of this pressure. Even if the temperature be not above the critical point, it must be near that point; and the recent researches of Ramsay and Young (Phil. Trans. 1886, pt. i. p. 123; 1887 (vol. 178), pp. 57 and 313), afford ample confirmation of the fact, first observed in 1835 by Thilorier in the case of carbonic anhydride, that near the critical point a substance in the liquid state is even more compressible than in the gaseous state above that temperature.

To sum up. If the upper layers are by lateral pressure thrown into long geo-clines, there will be from this cause an increased pressure beneath the geo-synclines, and a diminished pressure beneath the geo-anticlines. The pressure on the geo-synclinal area will be increased by sedimentation, while that on the geo-anticlinal area will be diminished by denudation. This increased pressure beneath the area of sedimentation may, it is suggested, squeeze some of the underlying magma into a solid state, thus giving rise to contraction and further subsidence. It may also cause the further compression of the water gas contained in the magma, thus giving rise to further

contraction and yet further subsidence. Conversely beneath an area of denudation the decreased pressure may allow some of the solidified magma (kept solid by pressure) to liquefy, thus giving rise to expansion and uplift. It may also permit the expansion of the water gas contained in the magma, and thus give rise to further expansion and uplift. And if, as some geologists have contended, loading and unloading are in themselves sufficient directly to depress or to cause the uplift of a flexible crust, it is clear that subsidence will more readily take place in that area which is not only being loaded above, but is being also thickened below by the condensation of the magma into solid; and that uplift will be more readily effected where the crust is not only being denuded above, but being eaten into by the melting of the underlayers below.

May we not perhaps account on somewhat similar principles for the existence of the underlying liquid or viscous substratum? Mr. Mellard Reade and Mr. Davison have lately independently pointed out that, owing to the cooling and contraction of the earth's crust, there is at some depth beneath the surface a level of no stress, where there is neither lateral compression nor extension, though the rocks are of course subject to the vertical pressure of the overload. Above this level the rocks are subject to compressive stress, and below this level to tensile stress. Picture the earth as composed, onion-fashion, of a number of concentric shells, and fix the attention on one of these shells at a depth of say three miles from the surface. Suppose this shell to be cooling and undergoing contraction. The shrinkage thus brought about will throw the shell into a state of tensile strain (like the oft-washed flannel shirt which has become uncomfortably tight). Now transfer the attention to the fact that the shells interior to the one we have selected are contracting. The shell has to fit a continually diminishing nucleus (like the frock-coat of a man who is rapidly losing flesh). In accommodating itself to this shrinking nucleus, the shell is subject to compressive stress. The question is, then, with regard to any given shell, Which tendency predominates—the compressive stress due to the radial contraction of the sphere, or the tensile stress due to the circumferential contraction of the zone in question? At the level of no stress these tendencies are equal and opposite: above that level compressive stress predominates: below that level tensile stress predominates. According to Mr. Davison (Phil. Trans. 1887) the level of no stress lies five miles deep from the surface; according to Mr. Mellard Reade (Origin of Mountain Ranges, p. 125), it may be taken to lie at a depth of one mile: Mr. Osmond Fisher would reduce this to less than a mile (Phil. Mag. Jan. 1888).

Is it not possible, I would suggest, that throughout the zone of maximum tension, due to circumferential contraction, the rocks may be rendered fluid by relief of pressure?

I have now sketched out in briefest possible outline the suggestion or suggestions I have to offer with regard to elevation and subsidence. I have introduced no calculations of the amounts of upheaval or subsidence. Although it is easy to see that the accumu-

lation of 12000 feet of Coal-measures in South Wales would involve a very material increase of pressure on the underlayers, I am of opinion that numerical calculations in these matters are only too apt to mislead by throwing a glamour of apparent mathematical accuracy over problems concerning which the most noteworthy feature is our profound ignorance. As in so many questions connected with the physics of the earth's crust our data here are too scanty and too indefinite to make numerical calculations of much value. Who shall presume to assign quantitative shares (+ or —) to (1) contraction due to metamorphism in the solid underlayers; (2) expansion of the rocks under increment of temperature; (3) the formation of geo-clines by lateral pressure; (4) contraction and expansion on melting and solidification; (5) the effects of pressure on the water gas contained in the fluid magma; (6) the differential load on a flexible crust? I for one will not. It is presumption enough in me to have ventured at all among the cross-currents of so difficult a sea, where to steer a mathematical course is impossible, and the best one can hope for is to keep one's craft afloat.

III.—Note on the Structure of the Ightham Stone.

By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

SOME time since a student of University College, Mr. J. Hale, of Ivy Hatch, brought to me specimens of an extremely hard green sandstone, which he informed me came from the Folkestone Sand stage near Ightham, in Kent. As the microscopic structure proved rather interesting, I lately visited the locality in his company, and had the additional advantage of being conducted by Mr. B. Harrison, of Ightham, so well known for his discoveries of palæolithic implements and for his minute knowledge of the geology of the neighbourhood.

The rock is briefly noticed in Mr. Topley's excellent Survey Memoir on the Geology of the Weald, in the following terms (p. 140):—"At Ightham, near the Roman Camp, is a hard white sandstone five feet thick, a good deal like the 'Greywether' sandstone of the Tertiary, and there is too another kind of stone, not observed elsewhere, a hard and tough dark green sandstone or rather grit. This was not seen in place, but on Ightham Common it is found in large masses, and is there called Ightham Stone and sometimes Firestone, from its being sufficiently hard to strike fire well."

The white sandstone is well exposed at the top of the northern escarpment of the commanding elevation of Oldbury Hill, and its craggy outcrop forms a part of the defence of the ancient camp. The rock appeared to me to vary in thickness and to be somewhat lenticular in its mode of occurrence.[1] Beneath the camp it is underlain by soft ferruginous sand, but a short distance to the south and a few feet below, another mass of sandstone crops out, which however is not nearly so hard. This seems to increase rapidly in thickness, and to be soon full ten feet thick, and perhaps more. On the

[1] Mr. Harrison informs me it is about 140 feet above the top of the Kentish Rag.

south-eastern side of a little combe we again find the hard white sandstone, capping a spur of the hill, and about three yards below it the softer bed crops out. I have examined microscopically the hard bed, which recalled to my mind, before I had read the passage quoted above, some of the hardest 'greywethers.' It consists almost wholly of fairly angular to subangular quartz grains, commonly about ·0125″ in diameter, which are probably derived from some granitoid rock, but do not exhibit any minor peculiarities worthy of remark. These are cemented by secondary quartz, in no great quantity, which is sometimes, but not always, in perfect optical continuity with the original grains, which often appear enclosed by coloured rings when viewed with crossed Nicols; probably from causes similar to that which produces them in separate grains and chips. There are a few grains showing a minute chalcedonic structure and one or two of brown or nearly black iron oxide. Parts of the slide also have a rather dirty look—in short, the rock is very like one of the hard grits or less perfect quartzites that one finds among the older Palæozoic rocks.

The other rock mentioned above is peculiar. It is of a glaucous green colour, varying somewhat in depth, and it weathers on the outside to a rusty brown. This suggests that the tint is due to a silicate of iron, and in the process of weathering the cementing mineral appears to be partially removed; for the discoloured portion, often an inch or so in depth, is less solid than the rest of the rock. Occasionally a smooth face of a fragment—probably an old divisional surface—has a kind of glazing of the green-coloured substance. The stone probably occurs *in situ* at a slightly higher level in the Folkestone Sands (here about 100 feet thick) than the white rock, for shallow pits have been dug in search of it over the upper part of Oldbury Hill.[1] Boulders also were formerly abundant over the surface in many places, resulting from past denudation. Some also, like erratics, as Mr. Harrison informed me, have been transported northward and eastward for more than a mile, and may be found lying on the lowland of Gault almost as far as the base of the escarpment of the North Downs.[2]

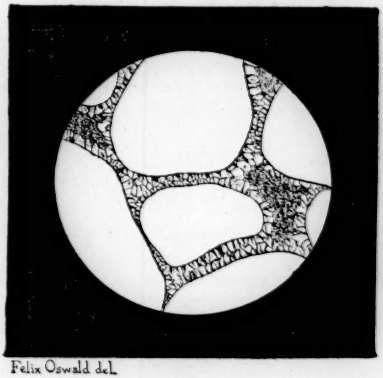
The mode of working for the masses of green rock suggests that, like the Sarsen-stones of the Tertiary and the Cornstones of older rocks, they are of concretionary origin. The rock is not generally seen *in situ*, but Mr. Hale took me to a sandpit where two masses were exposed. The opening was some 20 feet deep. In the lower part the sand was markedly false-bedded, being in the upper fairly horizontal, with alternating coarser and finer bands of white, pale red, or brownish colour. To a depth of perhaps a couple of yards the usual flaggy masses of sand cemented by limonite were common. The two blocks of green 'quartzite' were nearly on the same level,

[1] Mr. Harrison informs me that when the rock was extensively worked for the Metropolitan roads, some half-century since, it always occurred in detached masses, so that the opener of a pit might get sometimes nothing, sometimes a rich return, for his pains.

[2] The surface of the ground at the Camp is from about 500 to 600 feet, of the Gault about 300 feet above the sea.

one being rather less than a foot in thickness, the other perhaps about six inches,[1] and well-defined bands of ironstone extended for a foot or so below them. Beneath them consolidated sand was rare or absent. The relation of these masses to the surrounding sand left no doubt in my mind that they were of concretionary origin; the sand being cemented by deposition of secondary silica.

When examined with the microscope the green rock is found to consist almost entirely of grains of quartz, often about ·02″ or ·025″ diameter, which for the most part are remarkably well rounded. These contain, in variable number, cavities, generally very small and commonly empty, and occasional microlithic enclosures, such as hair-like belonites, brownish-olive films (mica or in some cases tourmaline?), and occasionally zircon. One grain also contains a number of yellowish-brown needles about ·005″ long. The general aspect of these grains leads me to conclude that they have been derived from a granitoid rock. With them occur a few grains of a chert (perhaps not generally so well rounded) varying in colour from brown to colourless, and sometimes apparently containing fragments of organisms. Rounded grains of limonite also occur as is common in the Folkestone Sand. There are also a few fragments distinctly of organic origin, presently to be described. The cementing material is chalcedonic quartz, the tiny crystals commonly growing outwards from each sand-grain, like a fringe, having a moderately distinct radial arrangement. The surfaces of adjacent grains are rarely quite in contact, but even at the nearest parts are separated by a thin



Felix Oswald del.

Ightham Stone × 35.

film of microcrystalline silica. Now and then an interspace between the fringes is occupied by chalcedonic silica, confusedly arranged, or more rarely by limonite, which probably is associated with silica. Occasionally brown films may be noticed in the quartz grains themselves, as though the limonite had made its way into cracks. The

[1] From their position in the scarped face of the sand, they could not be reached for measurement without an amount of trouble that would have been wasted.

lighter varieties of the rock exhibit under the microscope no indication of the colouring matter, except, perhaps, that the boundary of grains appears somewhat more definitely marked than is usual in a colourless quartzite, but in some of the darker specimens a thin greenish-coloured film can be detected round each grain, and the same tint is disseminated through the microcrystalline 'cement.' It would appear then that the first stage of consolidation was the deposit of a film of iron-silicate, minute quantities of which were from time to time precipitated during the formation of the chalcedonic quartz. The figure represents, somewhat diagrammatically, the general structure of the rock, omitting the organisms and darker grains.

The fragmentary organisms contained in this rock are not very common. Those which I have noticed are not much larger than the sand grains, and are often somewhat cylindrical in form. They can be readily detected with a good lens. With the exception of a few which resemble Annelid tubes, but may possibly be inorganic, they are of a pale green colour, and appear to have a slightly roughened surface, one or two much resembling bits of small spines of an Echinid. When seen under the microscope, they exhibit a peculiar reticulate structure, dark in colour, with the interspaces occupied by microcrystalline silica. I have no doubt they are really from an Echinid, some being probably bits of the test, while others are from the spines. One slide gives a very good transverse section of a spine about ·14″ in diameter.[1] I note also a longitudinal section of a moderately elongated spiral Gasteropod, about ·25″ long, with one or two other fragments, of the nature of which I am doubtful.

So far as I am aware this conversion of a sandstone into a quartzite by the deposition of chalcedonic silica is rare among the older rocks. In my own researches I have never come across a case, but Prof. R. D. Irvine mentions its occurrence among the older American quartzites, and figures an example from a cherty Potsdam sandstone from Wisconsin.[2] It occurs also in the 'Sarsen stones' and in the matrix of the Hertfordshire 'Puddingstone,' but in all these cases (so far as I know) the growth of the chalcedonic silica is much less regular than in the rock which I have described. But after I had examined the above described specimens, Miss C. A. Raisin, who at my request had undertaken the investigation of a parcel of rocks from Somali-land, found a very similar case, which will be noticed in the account which she is preparing.

IV.—Age of the Clwydian Caves.

By C. E. De Rance, F.G.S., A.I.C.E.

THE following abstracts of early papers, on the Cefn Caves, throw a most interesting light on the sequence and method of occurrence of the deposits found at the Tremeirchion Caves, which are

[1] I have to thank Dr. G. J. Hinde for specimens for comparison. The genera *Pseudodiadema* and *Peltastes* seem to be most common in the Upper Neocomian rocks of England. So far as I can judge, I should refer these spines to the former genus.

[2] Fifth Annual Report of the U.S. Geol. Survey, plate xxxi.

four miles east-north-east of them, and on the opposite side of the Elwy and Clwyd valley.

In February, 1832, the Rev. Edward Stanley, afterwards Bishop of Norwich,[1] visited the Cefn Cave, and found the bones of animals, stags' horns, and a human skull pierced with some sharp implement; he was then shown a new cave, about 100 feet above the lower one, and about 40 or 50 feet below the summit; it was discovered in cutting new walks on the hill-side constructed by the owner, Edward Lloyd, Esq.; he found the new cave to have two distinct entrances, the western being full of bone-earth made of comminuted fragments of bone, with numerous large bones of animals, crushed apparently by hyænas, whose teeth were found to be numerous. The cave could then be followed a distance of about 80 feet, with a varying height of six to ten feet; the top portion was clear of material, but he considered that the mass of drift formerly "filled up every cranny and fissure to the very roof." From this examination and another made on the 4th of April, he found the beds to consist "of fine loam, or clay of an ochrey colour and calcareous nature, readily effervescing with acids; generally speaking, the mass is deposited in horizontal laminæ, portions of which may be readily detached, but broken in upon, without order or regularity, by pieces of limestone, which, from their position and angular form, have evidently fallen from the roof. Bones were numerous, and broken pieces of hazel or birch occurred."[2] Mr. J. E. Bowman[3] carried his examination 25 feet beyond that of Dr. Stanley; he found the surface of the drift to be 18 inches beneath the roof of "the cavern" (upper cavern of Stanley); he infers from the trough-shaped entrance, and from the presence of sand and gravel in the cavern, that "the cave must have been a watercourse." He found the section to be as follows:—

1. Innumerable laminæ of impalpable mud or silt, alternating reddish (effervescing) bands, and pale ochreous layers that do not effervesce 1′·6″ to 2′·0″.

2. Marl or clay with angular limestone, and water-worn pebbles, with bones and teeth a little way from the top, increasing downwards into a pure bone-earth, containing Hyænas, Rhinoceros, etc., about two feet.

3. Compact "diluvium of clay," with pebbles of clay-slates, and a few splintered bones, and stalactites, two feet.

4. Coarse and fine sand, loam, and clay, no bones, pebbles, or shells, three feet.

Mr. Joshua Trimmer,[4] in 1838, describes in a paper published in full in 1841,[5] the Cefn Cave as occurring at the point in which the erratic gravel of the eastern and northern side of the Cambrian passes into the district overspread with detritus from Cumberland;

[1] Father of Dr. Stanley, Dean of Westminster.

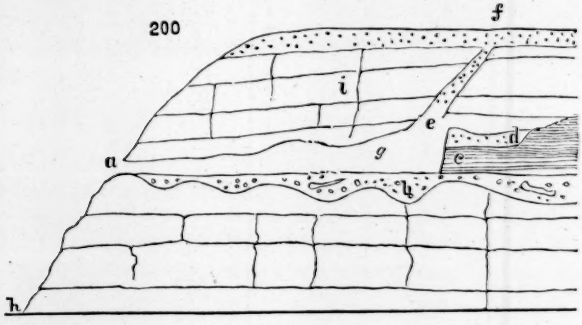
[2] Edinburgh New Phil. Journ. vol. xiv. p. 40–53; Proc. Geol. Soc. London, vol. i. p. 402 (abstract).

[3] J. E. Bowman, Cefn Bone Caves, Brit. Assoc. 1836.

[4] Trimmer, Cefn Bone Caves, Brit. Assoc. Report for 1838, London, 1839.

[5] Practical Geology and Mineralogy, London, John W. Parker, West Strand, 1841, p. 400, etc.

in a gorge of the Elwy, a little above its junction with the Clwyd, its mouth being 100 feet above the river and 200 feet above the sea; the cavern, he states, communicates with the surface by fissures, which, like the surface, are occupied by Northern Drift. Sedimentary deposits containing bones and teeth of Hyæna, Bear, and Rhinoceros, filled the cavern mostly to the roof; these were divided into two beds by a crust of stalagmite; the lower bed, he states, "was below the level of the entrance from the face of the cliff, and contains bones and teeth enveloped in sediment, and mixed with smooth pebbles like those of the adjacent river, and fragments of wood." Above the stalagmite the upper bed consisted of "calcareous loam containing bones and angular fragments of limestone, on the surface of which," he stated, "are sand and marl containing fragments of marine shells like those dispersed over the neighbouring district. The sediment within the cave is generally finely laminated." The author points out that the lower bed must have been derived from the river, when it flowed at a different level; he states that marks of teeth on the bones prove the cave to have been the home of carnivora, and that it was subaerial for some time, allowing the stalagmite to form, and states, that Dr. Traill noticed that the laminæ of the overlying deposit conform to the dip of the limestone, and attributes this also to fluviatile action, subsequent to the marine irruption from above. Mr. Trimmer illustrates his remarks by the following section:



a. Level of the entrance of the cave.
b. Deposit of mud, covered by stalagmite and containing bones, with rounded pebbles of grauwacke and limestone and pieces of wood.
c. Mud, bones, and angular fragments of limestone.
d. Sand and silt, with fragments of marine shells.
e. A fissure communicating with the surface.
f. Northern drift spread over the surface of the country.
g. Portion of the cave cleared of mud.
h. River Elwy, 100 feet below the cave.
i. Limestone rock.

In 1863 the "Geologist"[1] states that bones in the possession of Colonel Watkin Wynn, discovered in the Cefn Cave, were examined and named by Dr. Falconer, and found to belong to

[1] Geologist, vol. vi. p. 114, 1863.

Elephas antiquus, Rhinoceros hemitœchus, Rhinoceros tichorhinus, Hippopotamus major, Bos sp., *Cervus* sp., and others, and states that Dr. Falconer and Professor (now Sir Andrew) Ramsay together discovered fragments of Cockles and other marine shells in the clay, and amongst gravel and stones, with which the cave is filled.[1] Sir Andrew Ramsay himself refers[2] to this discovery, and states that the Cefn caves "were below the sea during part of the Glacial Epoch, for the Boulder-clay beds reach a higher level, and with Dr. Falconer I found fragments of marine shells in the cave overlying the detritus that held the bones of elephants and other mammalia."

No reference is made by Dr. Buckland, in the "Reliquiæ Diluvianæ," to the Cefn Cave, but he quotes Pennant as to the discovery of two molar teeth and tusk of Mammoth at Halkin Mine at the mouth of the Vale of Clwyd, which was probably the Talargoch Mine, of which Dr. Buckland gives the following section :—

	Yds.	Ft.
Vegetable mould	0	2
Clay	26	0
Sand and Gravel	68	0

He states that pebbles of lead and some pebbles of copper occurred in the gravel, and that horns, teeth, and bones of Mammals occurred at from 40 to 70 yards from the surface, and also in the bottom bed resting on the subjacent rock.

Mr. Mackintosh[3] found the "sand with minute fragments of sea shells, still adhering to one side, of a rising branch" of the cavern "ascended by steps." On the 22nd of May last Mr. Bouverie Luxmoore, F.G.S., and the writer, found this bed still visible, fragments of *Tellina Balthica* being determinable.

From these observations it is obvious that the bones discovered belonged to Mammals, who lived before the filling up of the Vale of Clwyd, and the sealing of its cavern by Glacial Drift.

V.—Notes on the Igneous Rocks of the Lleyn Promontory.

By J. Vincent Elsden, B.Sc. (Lond.), F.C.S.

MANY of the rocks of this district have been already described by the late Mr. E. B. Tawney, in a series of papers entitled "Woodwardian Laboratory Notes," contributed to the Geological Magazine a few years ago. The following additional remarks are to a certain extent supplemental to the above-mentioned papers, and are founded on a microscopical examination of a large series of rocks, collected some few years ago during a brief visit to the Lleyn district.

Commencing at the extreme end of the promontory, we find around Aberdaron three or four masses of intrusive rock, which are described in Mr. Tawney's paper as diabase, containing plagioclase often full of greenish microlites, augites in small quantity, of corroded outline and much altered into viridite, and a large quantity of black iron-

[1] Dr. Murchison states Dr. Falconer's visit was in August, 1859.
[2] Physical Geology and Geography of Great Britain, p. 462, 5th edition.
[3] Q.J.G.S., 1876.

oxide, both magnetite and ilmenite.[1] His specimens were selected from Pen-y-cil, Aberdaron quarry and Tynrhedyn, S. of Llanfaelrhys, and to his description of these rocks I find nothing to add, with the exception that one of my rocks taken from Pen-y-dre, close to Aberdaron, contains a much larger quantity of augite, in well-defined crystals.

The small isolated patches, lying to the North of Aberdaron, and coloured as serpentine on the Survey map, are not described in Mr. Tawney's paper. I obtained specimens of these so-called serpentines from Hendrefor, Ty-hen and Methlan. The rock from the last-mentioned locality appears under the microscope to consist of a network of plagioclase crystals, sometimes polarising brilliantly, but generally clouded with minute enclosures and decomposition products. The felspars are seen penetrating plates of augite, with brilliant polarisation colours. The whole rock is traversed by veins of serpentinous substance, and there are many patches of viridite. Biotite is sparingly represented and probably of secondary origin. Titaniferous iron, mostly decomposed into leucoxene, is present, and some bronze crystals of pyrite are seen by reflected light. Although there is far more serpentinous and viriditic matter than in the rocks of Aberdaron, iron separation has been less extensive.

The specimen from Ty-hen is finer-grained, and the felspars much more decomposed. The interspaces are chiefly filled with green fibrous viridite, with aggregate polarisation. There is but little fresh augite, and a good deal of titaniferous iron generally altered into grey opaque leucoxene. Some threads of serpentinous substance also occur, and a little secondary biotite. Two specimens taken from the extreme margins of these small bosses are interesting examples of contact metamorphism. The felspar crystals become very minute, probably owing to more rapid consolidation, and portions of the surrounding sedimentary rock appear entangled in a confused way with the igneous matter.

Macroscopically these rocks are greenish-looking and sufficiently soft and serpentinous to account for the Survey colouring. They do not differ much, however, from the diabases around Aberdaron, except in their more pronounced viriditic decomposition.

We come now to the large mass of igneous rock extending from Mynydd Penarfynydd on the south to Mellteyrn on the north. The rocks of this area are especially interesting on account of their variety. Thus the western slopes of the Penarfynydd ridge, as shown by Mr. Tawney, are of olivine diabase, which he considered to be a dyke intrusive in the hornblendic diabase of which the rest of the ridge is composed. It must be mentioned also that Mr. Tawney was unsuccessful in his attempt to discover the locality from which Sedgwick procured his specimen of hornblende picrite in this vicinity. The specimens of hornblende diabase described in "Woodwardian Laboratory Notes" were taken one from Careg Llefain, and the other from near Plas Rhiw.

My first specimen, in connexion with this area, was taken from

[1] Geological Magazine, 1880, Decade II. Vol. VII. p. 214.

the northern flank of Mynydd-y-Graig, about midway between these last-named localities. In this rock plagioclase is abundant, but rather decomposed. The extinction angle is rather large, corresponding to anorthite. Some crystals look like orthoclase twinned on the Carlsbad type, but are shown by their symmetrical extinction of about 33° to the trace of the twinning plane to be plagioclase. The augite is sometimes tolerably fresh, extinguishing perfectly, but other crystals show aggregate polarisation. It is often interpenetrated by felspar, and the margins are developed into strongly dichroic brown hornblende. A brownish granular substance is often arranged in bands across the cleavage directions, and sometimes there are inclusions of hornblende. There is also a good deal of fibrous yellowish green viriditic substance, resulting probably from the decomposition of augite and hornblende. In one case lines of opaque granular decomposition product intersect at the characteristic prism angle of augite.

At Treheli the same general characteristics are noticed. Under the microscope the plagioclase is seen to be abundant, but rather decomposed. Where polarisation colours are still given, the extinctions are apparently not so high as in the last-mentioned specimen. The augite is also not so fresh: it occurs in irregular masses, often developed into hornblende. Some crystals have a central patch of decomposition product, giving aggregate polarisation, the margins extinguishing perfectly. In other cases the margins are decomposed and the centre fresh. Large masses of a clear pale yellow substance, with granular patches here and there, show between crossed Nicols a central dark patch, changing but little on rotation, surrounded by densely interlacing fibrous crystals, with brilliant aggregate polarisation and feebly pleochroic. These fibrous, tufted crystals occur chiefly at the junction of hornblende and augite. The hornblende is much less altered than the augite, many of the viridite patches being fringed by perfectly fresh-looking hornblende. Original magnetite seems scarce, but lines of secondary oxide of iron often mark the boundaries of augite crystals, the interior being occupied by viridite.

North of the road near Tyganol-bwlch-y-rhiw, we begin to approach the so-called Rhos Hirwaun syenite, and here the rock undergoes considerable change in character. The felspar is here very opaque, and often encloses green microliths. The augite seems to be nearly all converted into viridite, which is interpenetrated by the felspars. Even the apparently unaltered fragments give aggregate polarisation. Quartz is fairly abundant in crystals and irregular grains, and generally contains enclosures of apatite needles, as well as cloudy patches of fluid and gas cavities. No hornblende can be detected; but there are a few ill-defined flakes of brown mica. There is a fair quantity of magnetite, and some ilmenite, partly converted into leucoxene. This rock appears to be a quartz-diabase, but a comparison would be interesting with the diabase of Castell Carron, about two miles north of this point, in which Tawney recognized quartz of secondary origin.

Immediately around Meyllteyrn we find the whole rock consisting of a network of felspar prisms, generally rather turbid, the interspaces being filled with augite in every stage of decomposition into viridite. In one specimen not a fragment of unaltered augite remains, while in others some crystals are still very fresh, polarising brilliantly and extinguishing perfectly. One large patch of viridite has at its two extreme ends two small portions of still unaltered augite, which extinguish simultaneously, as if originally portions of one and the same crystal. Magnetite is not very abundant, and generally of secondary origin, forming imperfect skeletons of augite crystals. There is a fair quantity of ilmenite, but much decomposed into leucoxene, and pyrites is sparingly present.

It now remains, before leaving this tract of igneous rock, to mention the so-called Rhos Hirwaun syenite, which is mapped by the Survey as occurring in two isolated patches. It has been shown by Mr. Tawney that the boundaries of these patches are incorrectly mapped, for he describes specimens from Pen-y-gopa and Penllech (within the greenstone area) which should belong to the so-called syenite, while the rock of Clip-y-Cilfinhir is in reality a diabase.[1] The rock of Pen-y-gopa differs from that of Ty-mawr, described by Prof. Bonney,[2] in containing hornblende and but little mica, and is described as hornblendic gneiss. The specimen about to be described is taken from quite the other side of the main mass of this rock, from near Pen-y-bont, close to Llangwnadl. In the hand specimen this rock is an exceedingly tough fine-grained dark green hornblendic rock, traversed by fine veins of lighter green and speckled with small grains of quartz and felspar. Under the microscope the rock is seen to consist chiefly of dark greenish-brown hornblende, with characteristic cleavage and strongly dichroic where fresh, but the dichroism decreases rapidly with alteration, and it ultimately passes into a chloritic pseudomorph. The felspar is generally turbid, but here and there shows the characteristic twinning of plagioclase. Some orthoclase is also recognizable. The quartz is almost indistinguishable from the felspar except in polarised light, and is generally turbid with a multitude of minute cavities. A few crystals of magnetite and some pyrites are present.

On the whole this rock bears a much closer resemblance to the Pen-y-gopa specimen than to that of Ty-mawr, but there seems to be scarcely sufficient trace of foliation to entitle it to be classed as hornblendic gneiss.

Between Llanengan and Llangian are two small greenstone areas not touched in Mr. Tawney's paper. At Pen-y-gaer quite half this rock appears to consist of felspar, but much decomposed. The felspars form a network, filled up by augite, which it also penetrates deeply. The augite is brownish, with much iron separation along the cleavage cracks, and sometimes the whole crystal is rendered opaque from this cause. Scarcely any of the augite extinguishes

[1] Geological Magazine, Vol. X. p. 68.
[2] Q.J.G.S. vol. xxxv. p. 306.

completely between crossed Nicols. There is a good deal of strongly dichroic hornblende, sometimes intergrown with the augite, at other times in detached crystals. It generally polarises more brilliantly and extinguishes more thoroughly than the augite. Viridite patches are abundant, and a little secondary quartz occurs. Most of the iron oxide shows the grey decomposition product of ilmenite, but some pyrites is to be noticed. The same rock near Llangian is much more decomposed, the felspars being quite opaque and much viridite and opaque ferric matter present. Some of the viridite tracks appear to have outlines of augite crystals; one looking like an orthodiagonal section gave an angle of 135°, which nearly corresponds to the angle between ∞ P and ∞ P^{c} ∞ (clinopinacoid) in augite. Small quartz fissures traverse the rock.

We now pass to the large patch coloured as porphyry on the Survey Map, lying between Llanbedrog and Capel Ceidio. The southern portion of this area consists chiefly of quartz-felsite, and at Pig Street, Mr. Tawney described a volcanic ash. I find a coarse tuff on the south side of Mynydd Mynytho, and a similar kind of rock to the north of Madryn, at Y Gledrydd. My other specimens from this area do not differ essentially from those already described in Woodwardian Laboratory Notes.[1]

The Boduan mass of porphyrite is described from several localities in Mr. Tawney's paper. I will only add one more description of a rock taken from the extreme south side, near the village of Boduan. The rock here is much decomposed: the ground-mass is micro-crystalline, consisting of small felspar prisms, which from the small extinction angle is possibly oligoclase. Precise determination of the larger felspars, which occur porphyritically, is difficult owing to decomposition, but no orthoclase can be recognized with certainty. There is some glassy base between the crystals. A few magnetite grains and a good deal of opaque ferric matter occur throughout. No trace of hornblende remains, although a few feebly dichroic chloritic pseudomorphs are to be seen. This rock differs, therefore, from that of Carn Boduan.

Approaching Nevin the character of the rock changes considerably. I give a description of the rock near Nevin, which much resembles that described by Mr. Tawney as probably coming from Moel Gwyn, and which he classes as epidiorite. The large felspars are much decomposed, but are apparently triclinic: they are generally filled with a fine granular substance, and sometimes crowds of colourless microliths are visible with crossed Nicols. The ground-mass consists chiefly of quadrangular sections, with nearly parallel extinction, corresponding to oligoclase. Hornblende is present in detached crystals, which gradually lose their fibrous structure and dichroism and pass into chloritic pseudomorphs. A few remnants of augite are visible. Magnetite is abundantly associated with the decomposing hornblende, and there are some opaque rhombohedral crystal of ilmenite.

[1] Geological Magazine, Vol. X. p. 70.

We now come to the so-called serpentine of Porth Dinlleyn, described by Prof. Bonney in Q.J.G.S. vol. xxxvii. p. 48, and identified as altered diabase-tuffs, decomposed diabases and basalts. His specimens were selected exclusively from the eastern side of the peninsula. I therefore proceed to the west side of the promontory. Near the "Ancient Fortress" the rock appears to be a true diabase, and shows under the microscope a network of felspar, too clouded for determination of extinction angles. Strings of serpentinous matter and a good many viridite patches are scattered through the slide. Pale brownish augite occurs in small crystalline grains still polarising brilliantly. The opaque bodies are not abundant, and seem to consist entirely of magnetite and some pyrites. A little further south the rock is very similar to the above. About half the slide consists of prisms of felspar, sometimes polarising brilliantly, but generally decomposed. The extinctions are at a somewhat high angle to the trace of the twinning plane. Some of the felspars are porphyritic, with broken outlines. Augite is sparingly represented in detached grains and crystals, rather deeply coloured, and showing marked pleochroism. A good deal of greenish decomposition product occurs between the felspar crystals, and magnetite, ilmenite and some pyrites are scattered throughout. Apatite needles and a little biotite also occur here. Some of the felspars show a tendency to to saussuritic decomposition, giving aggregate polarisation, and greenish alteration products with some epidote.

Still further south the rock becomes more serpentinous in appearance, and under the microscope more than half the slide is seen to consist of bright green serpentine, the remainder being an opaque, greyish substance, interpenetrated everywhere by serpentinous matter. Patches of calcite abound, and threads of the same mineral traverse the serpentine. Innumerable bands of dark granular matter, in more or less wavy parallel lines, occur throughout. These under higher powers transmit feeble brownish colours, and have the appearance of picotite. This is so far as I know the only instance of the occurrence of a rock approaching the character of true serpentine in Lleyn. The arrangement of the opaque bands is not such as to recall the "maschen structur" of peridotic serpentines, but possibly as my specimen was taken from the junction of the rock, we may have here the results of contact metamorphism of the surrounding schists.

The greenstone dykes of Porth-wen appear to be chiefly dolerite. Under the microscope the rock appears to be crowded with lath-shaped crystals of felspar, no longer polarising in very bright colours. A good deal of viridite and some biotite are present. Olivine crystals are almost entirely altered, but are still recognizable. Augite also remains, but generally very opaque, from iron separation. A good deal of secondary calcite is seen, as well as magnetite and pyrites.

VI.—Note on the Classification of the Ichthyopterygia (with a Notice of Two New Species).

By R. Lydekker, B.A., F.G.S., etc.

Having devoted several weeks to the study of the magnificent collection of the remains of Ichthyopterygians preserved in the British Museum (Natural History), I purpose on this occasion to give a brief notice of some of the conclusions at which I have arrived, since a considerable interval will elapse before the publication of that part of the Museum "Catalogue of Fossil Reptilia" in which my observations will be more fully recorded.

Exclusive of the genus *Cetarthrosaurus*, which is referred by Mr. Hulke to the *Mosasauridæ*, four genera of Ichthyopterygia have hitherto been described; viz. *Ophthalmosaurus*, Seeley, *Baptanodon* (*Sauranodon*), Marsh, *Ichthyosaurus*, König, and *Mixosaurus*, Baur. Since, however, there appear to be no characters by which *Baptanodon* can be generically separated from *Ophthalmosaurus*, I am inclined to follow the suggestion made by Dr. Baur, and unite the two; thus reducing the number of genera to three. With regard to *Ichthyosaurus*, it has been suggested by more than one writer that this genus is susceptible of division into two or more genera; and there is much to be said for this view, since there is an extraordinary amount of structural difference between many of the forms. If, however, the species be arranged in their natural relationship, which corresponds to a great extent with their distribution in time, it will be found that these distinctive characters tend to shade more or less completely into one another. Since, moreover, the skulls of all the species seem to be so nearly alike in general structure that it is very improbable that good generic characters could be drawn from them, I have come to the conclusion that it will be more convenient to the palæontologist, and most certainly to the pure geologist, to retain the genus in its original wide sense. I intentionally use the term convenient in this conjunction because I am glad to see that Prof. Flower,[1] in his recently published memoir on the Liberian *Hippopotamus*, has expressed his opinion very clearly that the restriction or multiplication of generic terms is purely and simply a matter of convenience; and that their multiplication rather tends to make us lose sight of the mutual relationship of allied forms. I am further convinced of the advisability of retaining the original use of the term *Ichthyosaurus*, because if we once begin to subdivide it, it will be almost impossible to know where to stop.

Dr. Baur, who adopts the view of the advisability of splitting up the type genus, makes the three above-mentioned genera the types of three distinct families; but if the term *Ichthyosaurus* be employed in the sense indicated above, it appears to me that the whole three genera may be conveniently included in a single family—the *Ichthyosauridæ*.

The last-mentioned writer has shown very clearly that while *Ichthyosaurus* occupies the middle position, *Ophthalmosaurus* is the

[1] P.Z.S. 1887, p. 614.

most, and *Mixosaurus* the least, specialized genus; and I find that while among the Liassic species *Ichthyosaurus communis* in the structure of its limbs makes the nearest approach to *Ophthalmosaurus*, *I. tenuirostris* and its allies are the forms most nearly allied to *Mixosaurus*. Now the pectoral limb of the generalized *I. tenuirostris* having only four digits, while in the more specialized species the number is greatly increased, it may be inferred that Ichthyosaurs have descended from a tetradactylate ancestor, or at least that only four digits have been primarily modified into the Ichthyosaurian paddle. A comparison of the pectoral limb of *I. tenuirostris* with that of *Chelydra* has moreover led me to conclude that the four digits there found correspond to the 2nd, 3rd, 4th, and 5th of the typical manus; the 3rd arising in the same way from the intermedium, and the 4th and 5th conjointly from the ulnare. The primary grouping of the genus which I have adopted is mainly based upon the simpler or more complex structure of the pectoral limb; and I may add that in those forms where the original four digits have become split up it is evident that the presence of two centralia in the carpus is an acquired and not an inherited character. This classification is in the main a modification of the one proposed by A. Wagner, and subsequently extended by Col. Kiprijanoff in the Memoirs of the St. Petersburg Academy for 1881. It is briefly summarized in the following table, which contains a synopsis of all the named species with which I am acquainted. The specific names applied by Hawkins to several of the English Liassic species are, however, omitted. In cases where the generic position of species is uncertain a note of interrogation is placed after the generic name; and when the serial position is provisional an asterisk is prefixed :—

I. Genus Ophthalmosaurus, Seeley (*Baptanodon* = *Sauranodon*, Marsh).—Humerus articulating distally with three bones.

1. Ophthalmosaurus icenicus, Seeley. Oxford and Kimeridge Clays, England.
2. Ophthalmosaurus natans (Marsh). Up. Jurassic, N. America.
3. „ discus (Marsh). „ „ „
4. „ cantabrigiensis, n.sp. *nobis*. Cambridge, Greensand.

II. Genus Ichthyosaurus, König.—Humerus articulating distally with only the radius and ulna, which are short and in close apposition.

A. Latipinnate Group.—Pectoral limb with the third digit (that arising from the intermedium) containing two longitudinal rows of bones and two centralia; radius very short, with entire anterior border.

a. Campylodont subgroup.—Roots of the teeth enveloped in cement; humerus with prominent trochanteric ridge.

a. Femur very short, with trochanteric ridge enormously developed.

5. Ichthyosaurus campylodon, Carter. Up. Cretaceous, Europe.
*6. „ indicus, *nobis*. Up. Cretaceous, S. India.
*7. „ Strombecki, Meyer. Neocomian, N. Germany.
*8. „ polyptychodon, Koken. Neocomian,. North Germany.

β. Femur longer, with trochanteric ridge less developed.

*9. Ichthyosaurus (?) ovalis, Phillips. Kimeridge Clay, Eng.

*10. „ (?) thyreospondylus, Phillips. Kimeridge Clay, England.

Syn. (?) *I. brachyspondylus*, Owen.
(?) *I. thyreospondylus*, Owen.

11. Ichthyosaurus leptospondylus, Wagner. Kimeridgian, Bavaria.

12. Ichthyosaurus entheciodon, Hulke. Kimeridge Clay, England.

13. Ichthyosaurus trigonus, Owen. Kimeridge and Oxford Clays, England.

Syn. (?) *I. posthumus*, Wagner. Kimeridgian, Bavaria.

*14. Ichthyosaurus (?) dilatatus, Phillips. Kimeridge and Oxford Clays, England.

*15. Ichthyosaurus hildesiensis, Koken. Neocomian, North Germany.

b. Typical subgroup.—Roots of the teeth without cement; humerus without prominent trochanteric ridge.

16. Ichthyosaurus communis, Conybeare. Low. Lias, England.

17. „ breviceps, Owen. „ „

18. „ Conybeari, n.sp., *nobis*. „ „

19. „ intermedius, Conybeare. „ „

B.—Longipinnate Group.—Pectoral limb with the third digit containing one longitudinal row of bones and a single centrale; radius nearly square, and usually with notched anterior border.

a. Acutirostrine subgroup.—Teeth small and cylindrical, coracoid without posterior notch; head of humerus oblong.

20. Ichthyosaurus integer, Bronn. Up. Lias, Würtemberg and (?) England.

21. Ichthyosaurus acutirostris, Owen. Up. Lias, Europe.

Syn. *I. longipennis*, Mantell.
I. microdon, Wagner.
I. quadriscissus, Quenstedt.
I. Zetlandicus, Seeley.
I. longifrons, Owen.

b.—Tenuirostrine subgroup.—Teeth small and cylindrical; coracoid with posterior notch; head of humerus triangular.

22. Ichthyosaurus tenuirostris, Conybeare. Lias, Europe.

Syn. *I. grandipes*, Sharpe.

23. Ichthyosaurus latifrons, König. Lias, England.

Syn. *I. longirostris*, Owen.
(?) *I. longirostris*, Jäger.

c. Platyodont subgroup.—Teeth large, either cylindrical or carinated; coracoid without posterior notch; head of humerus triangular.

24. Ichthyosaurus lonchiodon, Owen. Low. Lias, England.

25. „ „ platyodon, Conybeare. Low. Lias, England.

Syn. *Ichthyosaurus giganteus*, Leach.

26. Ichthyosaurus trigonodon, Theodori. Up. Lias, Bavaria.

III. Genus Mixosaurus, Baur. Humerus articulating with the radius and ulna, which are elongated and separated by an interval.

27. Mixosaurus cornalianus (Basani). Up. Lias, Italy.
Syn. *Ichthyosaurus cornalianus*, Basani.

The forms indicated by the under-mentioned names cannot be classified, and it is probable that several of them are synonyms of those already mentioned.

28. *Ichthyosaurus æqualis*, Phillips. Kimeridge Clay, England.
29. „ „ *angustidens*, Seeley. Up. Chalk, England.
30. „ „ (?) *atavus*, Quenstedt. Mid Trias, Germany.
31. „ „ *australis*, Hector. (?) Trias, New Zealand.
(?) = *Mixosaurus*.
32. „ „ *calorodirus*, Seeley. Kimeridge Clay, England.
33. „ „ (?) *carinatus*, Sauvage. Up. Trias, France.
? = *Mixosaurus*.
34. „ „ *coniformis*, Harlan. ? Lias.
35. „ „ *crassicostatus*, Theodori. Up. Lias, Bavaria.
36. „ „ *gaudensis*, Hulke. Reputed Miocene, Malta.
37. „ „ *hexagonus*, Theodori. Up. Lias, Bavaria.
38. „ „ *hygrodirus*, Seeley. Kimeridge Clay, England.
39. „ „ *ingens*, Theodori. Up. Lias, Bavaria.
40. „ „ *macrophthalmus*, Theodori. Up. Lias, Bavaria.
41. „ „ *megalodirus*, Seeley. Oxford Clay, England.
42. „ „ *Nordenskiöldi*, Hulke. Trias (?), Spitzbergen.
43. „ „ *planartus*, Theodori. Up. Lias, Bavaria.
44. „ „ *polaris*, Hulke. Trias (?), Spitzbergen.
45. „ „ (?) *rheticus*, Sauvage. Up. Trias, France.
(?) = *Mixosaurus*.
46. „ „ *triscissus*, Quenstedt. Up. Lias, Würtemberg.

The name *I. latimanus*, as will be noticed below, must be discarded. The names *I. Bonneyi*, *I. Doughtyi*, and *I. platymerus*, Seeley, and *I. advenus*, Phillips, are merely MS. ones; the first three being applied to specimens from the Cambridge Greensand, and the fourth to vertebræ from the Stonesfield slate. *I. Walkeri*, Seeley, has been made the type of *Cetarthrosaurus*.

In regard to the two new species above mentioned *Ophthalmosaurus cantabrigiensis* is founded on a small humerus from the Cambridge Greensand in the British Museum (No. 43989), which differs from that of *O. icenicus* in having the three distal facets of nearly equal dimensions. The name *Ichthyosaurus Conybeari* is applied to an imperfect skeleton of a small Ichthyosaur in the same collection (No. 38523) from the Lower Lias of Lyme-Regis, which differs from *I. communis* in the notching of the anterior border of some of the phalangeals of the pectoral limb, and in the relatively longer skull; while it is distinguished from *I. intermedius* by the greater width of the pelvic limb. It is possible that *I. latimanus*, Owen, may be

identical with this form, but since, as I shall show on a subsequent occasion, that species appears to have been founded by mixing up the characters of two specimens, which are apparently specifically distinct, the name must be abolished.

It is not improbable that one or more of the Kimeridgian species mentioned in the Campylodont subgroup may be referable to *Ophthalmosaurus*, and I think there is considerable probability of this being the case with *Ichthyosaurus* (?) *ovalis*, in which the contour of the vertebræ differs considerably from that obtaining in Kimeridgian species undoubtedly belonging to *Ichthyosaurus*. It may therefore prove that *Ophthalmosaurus icenicus* is even specifically identical with this form. In respect of other species, I have great doubt whether *I. eutheciodon* is distinct from the continental *I. leptospondylus* of the same geological horizon, but since I cannot certainly say that the two are identical, it is preferable to allow both names to stand for the present. I find by a comparison of the type skulls of the so-called *I. Zetlandicus*[1] of the Upper Lias of Whitby, and *I. longifrons* of that of Normandy, that these two are evidently closely allied forms; and since certain differences in the arrangement of the bones of the quadratic region do not appear to me to be, at the most, of more than racial importance, I am inclined to refer both forms to a single species. A comparison of the pectoral limb of the Normandy form with that of the Whitby *I. acutirostris* shows, moreover, that both are of the same structural type; and since other Upper Liassic skulls from Whitby, which are indistinguishable from the type of *I. Zetlandicus*, agree equally closely with that of the former, I am disposed to unite both *I. Zetlandicus* and *I. longifrons* with *I. acutirostris*. I find, moreover, that skeletons from the Upper Lias of Würtemberg in the Museum, which agree with the one figured by Renevier in the "Bull. Soc. Vaudois" for 1885 as *I. quadriscissus*, Quenstedt, and also with those from the same region figured by Prof. Seeley in the "British Association Report" for 1880, without specific determination, present all the characters of the present species. And I am confirmed in this conclusion by finding it stated by Theodori in his Monograph of *I. trigonodon* that *I. acutirostris* is the most common form found in the Upper Lias of Bavaria and Würtemberg. The sketch of a skull from the Upper Lias of Banz, in Bavaria, made by Theodori and presented by him to Sir R. Owen, which is preserved in the British Museum, also affords important evidence in this direction, since it shows that the premaxilla and lachrymal did not unite below the nares to exclude the maxilla from that aperture;—a feature which is characteristic of the skulls described as *I. Zetlandicus* and *I. longifrons*.

I may observe also that, as Mr. W. Davies first pointed out to me, *I. longirostris*, Owen, appears to be identical with *I. latifrons*, König. The former name was, however, originally applied by Jäger

[1] I am glad to take this opportunity of thanking Prof. T. McKenny Hughes, of Cambridge, for his courtesy in permitting the type skull of *I. Zetlandicus* to be sent to the British Museum for comparison.

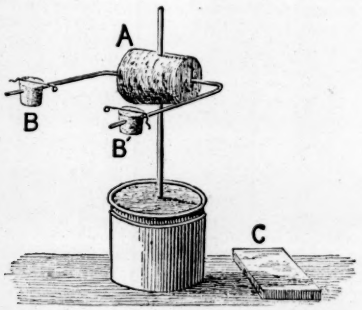
to specimens from the Upper Lias of Würtemberg which are probably also specifically the same.

In conclusion it will be interesting to draw attention to a pectoral limb of *I. acutirostris* (*quadriscissus*), figured by Dr. O. Fraas in the Jahresh. Ver. Nat. Württ., 1888, pl. vii., in which the contour of the integument is perceived. It appears from this figure that the integuments were produced a considerable distance on the posterior border of the paddle so as to form a large fold in the axillary region.

VII.—On Simple Apparatus for Use in the Observation of Flame-Reactions.

By Grenville A. J. Cole, F.G.S.

GEOLOGISTS, who are again and again forced to deal with the most minute or fragmentary specimens, and who find it impossible to cultivate, during their surveys of the earth, the methods perfected by the mineralogist in his learned leisure, have fully recognized the importance of Prof. Szabó's tabulation of the flame-reactions of the felspars. Since the accuracy of the results obtainable depends largely upon the position of the mineral-particle in the flame, I venture to call attention to a form of support that has proved in practice as convenient and efficient as it is simple.



Following a long way in the wake of Prof. Miller's ingenious goniometer, the materials of this little instrument are essentially wire and cork. A small gallipot, such as is used for Liebig's extract, forms a base that is clean, strong, and adequately heavy. A brass wire, about 5 mm. in diameter, passes through the cork of this, and rises 15 centimetres above it, carrying a stout cork A, which can be slid up and down to any level. A steel wire or knitting-needle, some 25 cm. long, is pushed horizontally through A, the last 7 cm. on either side being then bent forward at right angles. Two small corks, B and B′, are carried by the parallel arms thus formed, and support, by means of a knife-slit in the top of each, the fine platinum wires employed. B can be slipped off the steel wire, the mineral fragment can be attached, with Prof. Szabó's precautions, to the platinum loop, and the carrier replaced without fear of loss by jarring. B′ can be used for a type-specimen to be compared with that under examination, the wires on both corks being

adjusted to exactly the same level, and one or other being brought at will into the flame.

The cork A being set approximately at the proper height, the rotation of the steel wire within it moves B and B′ equally in vertical planes, and gives a delicate means of fine adjustment. To secure uniformity of position in successive experiments, the platinum loop carrying the specimen is brought, in the first trial, to the exact level of the top of the bunsen burner, or, in the second and third trials, to the level of the top of the iron cone. A small plate of wood, C, of the thickness of 5 mm., is then slid under the gallipot, the specimen being thus raised to the position adopted by Prof. Szabó, without any of the difficulties that so often arise from the jarring or stiffness of motion in more elaborate supports.

The dimensions above given are those adapted to a bunsen burner of ordinary height and ordinary diameter of base. For packing, the erection can be taken down, and the 5-millimetre plate and the smaller corks can be kept inside the gallipot till required.

This obvious and simple contrivance, with its smoothness and uniformity of adjustment, may possibly facilitate to some busy geologist the practice of the method of flame-reactions; and a sense of the value, not to say the charm, of the observations of Prof. Szabó must be my excuse for thus describing it at length.

VIII.—Note on a Species of *Scymnus* from the Upper Tertiary Formation of New Zealand.

By James W. Davis, F.G.S.

In a Memoir recently published "On the Fossil Fish Remains of the Tertiary and Cretaceo-Tertiary Formations of New Zealand" (Transactions of the Royal Dublin Society, vol. iv. ser. ii. p. 11, pl. vi. fig. 22) there is described a small tooth as an immature example of *Carcharodon angustidens*, Ag. The specimen was included amongst a large number of others forwarded for examination by Sir James Hector, Director-General of the Geological Survey of New Zealand; it is a small tooth, exquisitely preserved, and does not exhibit any signs of abrasion by use, which led to its being provisionally considered as the tooth of a young shark, and its form and minutely serrated margin appeared to indicate that its relationship was with *Carcharodon*. I am indebted to Mr. A. Smith Woodward for the suggestion that the tooth belongs to one of the Spinacidæ; a re-examination has convinced me of the correctness of this suggestion, and that it is an example of the genus *Scymnus*, to which genus I have no hesitation in transferring it. The occurrence of this specimen in the Napier series of the Esk River is interesting from the fact that the only existing species, *Scymnus lichia*, is found inhabiting the Mediterranean Sea, and that part of the Atlantic immediately adjoining. The genus is represented in the Miocene Molasse of Baltringen by *Scymnus triangulus*, Probst, a small thin tooth, with a triangular crown and a more or less rectangular base divided into two parts by a vertical slit; from the Pliocene of Tuscany

and the Bruxellian of Woluwe St. Lambert. The New Zealand species may be distinguished from this one by its larger size, more acuminate apex, and by a slight lateral projection from the base of the crown. The Napier series, from which it was obtained, occupies a much higher horizon than the Baltringen Molasse; by the Survey they are considered to be the Upper beds of the Pliocene, whilst Professor Hutton tabulates them as Pleistocene. They underlie the dispersed gravels and peat mosses, the latter containing the bones of the recently extinct Moa. Though the existence of *Scymnus* is unknown in the southern seas, its fossil remains in these beds indicate that its extinction has happened during comparatively recent times. It is desirable that the species should be distinguished, and I suggest as the *nomen triviale, Scymnus acutus.*

References to Species previously described.

Scymnus triangularis. J. Probst. Würth. Jahresb. v. xxxv. p. 175, pl. iii. figs. 35, 36 (1879). Molasse, Baltringen, Wurtemberg.

S. majori. R. Lawley. Nuovi Studi sopra ai Pesci, etc., p. 38, pl. i. fig. 17 (1876). Pliocene, Tuscany.

S. trituratus. J. Probst. Würth. Jahresb. v. xxxv. p. 176 (1879).

F. Noetling. Sitzb. Ges. Naturf. Freunde Berlin, 1886, p. 17 = *Corax trituratus.*

T. C. Winkler. Archiv. Mus. Teyler, v. iv. fasc. i. p. 27, pl. ii. fig. 13 (1874). Bruxellian, Woluwe St. Lambert, near Brussels.

Chevinedge, Halifax.

NOTICES OF MEMOIRS.

I.—Palæontological Contributions to Selachian Morphology.[1]

By A. Smith Woodward, F.Z.S., F.G.S.

THE author discussed two features in Selachian anatomy presented by fossils from the Chalk of Mount Lebanon. An examination of the so-called *Scyllium Sahel-Almæ*, which is certainly a member of the Scylliidæ, shows that the lateral line of this fish was supported by a series of half-rings, exactly like those met with in *Squaloraja* and the Chimæroids—a character apparently hitherto unrecognized among undoubted Selachii. The canal of the lateral line in the Cretaceous fossil was thus presumably an open groove; and only two living Sharks, *Echinorhinus* and *Chlamydoselachus*, both comparatively primitive, have yet been described as exhibiting such a condition. The second discussion related to the pelvic cartilage of *Cyclobatis*, one of the Trygonidæ. It had long been recognized that the pair of anterior processes were the homologues of the so-called "prepubics," and the author now attempted to show that the large bent, lateral processes were dorsally placed, and might thus be regarded as "iliac." It seems not improbable that the reflexed distal extremities of the latter originally supported the metapterygia of the pectoral fins, in the same manner as the propterygia were connected with the antorbital (post-palatine) cartilages.

[1] Proceedings of Zoological Society of London, Feb. 21, 1888.

II.—Unterdevonische Crinoiden. Von Dr. Otto Follmann. Verh. d. nat. Ver. Jahrg. xxxiv. 5 Folge, IV. Bd. pp. 113–138, pls. ii. iii.

THIS paper gives detailed descriptions of a numerous suite of Crinoids collected by Herr B. Stürtz from the Lower Devonian strata of Bundenbach and Gemünden. These fossils are mostly in a pyritized condition, but they have been treated by the same methods which proved so successful with the Asteroidea from the same beds, and many new structural features have been brought to light. The following new species are described and figured:—*Triacrinus elongatus, Calycanthocrinus* (n. g.) *decadactylus, Taxocrinus Stuertzii, T. Grebei, Codiacrinus Schultzei, Ctenocrinus aciculoris, C. stellifer,* and *C. rhenanus.* Additional details are likewise given of twelve other species previously described from the same geological horizon.

III.—Discovery of *Elephas primigenius* associated with Flint Implements at Southall. By J. Allen Brown, F.G.S., Geologists' Association, 6th May.

DURING last year some important drainage works were carried out at Southall, and sections were exposed in Windmill Lane, a road running from Greenford, through part of Hanwell, across the Great Western Railway to Woodlake, skirting Osterley Park, as well as in Norwood Lane, leading from Windmill Lane, south-westward.

The remains of the Mammoth were discovered in Norwood Lane, about 550 yards from its junction with Windmill Lane, and at the 88 foot contour. They were embedded in sandy loam, underlying evenly stratified sandy gravel, with a thin deposit of brick-earth about a foot in thickness, surmounting the gravel—in all about 13 feet of river drift above the fossils.

The labourers described the tusks as being found curving across the "shore" or excavation, attached to the skull, parts of which, with the leg-bones, etc., and teeth were exhumed. Other bones were exposed in the side of the cutting.

It is probable that the whole of the remains might have been obtained if they could have been carefully exhumed, and if means had been at hand to remove them, as they were in a soft pulpy condition.

The author obtained many of the bones in a fragmentary state, including parts of the fore limbs and jaw, and portions of the tusks, as well as two of the teeth, which were much better preserved; a third molar was found, but broken to pieces by the labourers. Although many of the bones were when gelatinized too much broken to admit of determination with certainty, they were quite unrolled and the joints and articulations of the leg bones and the teeth were unabraded. There can hardly be a doubt that the bones of the whole of the fore part of the Elephant, if not of the entire skeleton, were in juxtaposition.

Several flint implements were found in Norwood Lane in close

proximity to the remains, and a well-formed spear-head nearly five inches in length, of exactly the same shape as the spear-heads of obsidian until recently in use among the natives of the Admiralty Islands and other savages, was discovered in actual contact with the bones. Smaller spear-head flakes less symmetrically worked were also found at this spot. They are formed for easy insertion into the shafts by thinning out the butt end, similar to those found abundantly by the author at the workshop floor, Acton, and described by him in his lately published work, "Palæolithic Man in N.W. Middlesex." Among the implements found here is an unusually fine specimen of the St. Acheul or pointed type, 8 inches long, of rich ochreous colour and unabraded, and a well-formed lustrous thick oval implement pointed at one extremity, rounded at the other, and also unrolled.

From the adjacent excavations in the Windmill Road several good specimens of Palæolithic work were also obtained, including two dagger implements with heavy unworked butts and incurved sides converging to a long point; these were evidently intended to be used in the hand without hafting. Also a form of instrument characteristic of the older river drift, convex on one side and slightly concave on the other near the point and partly worked at the butt; with these were two rude choppers or axes, two points of implements with old surfaces of fracture, and several flakes. It is remarkable that almost all the principal types of flint implements found in the oldest drift deposits are represented in the collection found in the vicinity of the remains of the Elephant. Mr. J. Allen Brown accounts for the deposit of the remains of the Mammoth and associated human relics at this locality by the fact that the underlying Eocene bed rises to within two or three feet of the surface a few yards west of the spot where the bones and implements were found, while towards the Uxbridge Road and upper part of Windmill Lane, the drift deposits thicken, until at no great distance they have a thickness of 14 to 17 feet. Thus the river-drift rapidly thins out and the upward slope of the London Clay reaches nearly to the surface at about the 90th foot contour, and as the level at which the fossils were found (13 feet from the surface) would represent the extent of the erosion and infilling of the valley which had then taken place, it is probable that the higher ground formed by the up-slope of the London Clay then formed the banks of the ancient river, or if another thick bed of drift should be found still further west, in a depression of the Tertiary bed, such as often occurs. The intervening higher ground would form a small island in the stream, in either case a habitual land surface would be formed, with shallow tranquil waters near the banks, not impinged upon by the currents which subsequently set in this direction as shown by the deposit of coarse stratified gravel above the loamy bed and remains.

The author is thus led to the conclusion that the carcase of the Elephant either drifted into the shallow water near the bank, or else, which seems more probable from the presence of so many

weapons near the spot, including the spear-head, found with the remains, that the animal was pursued into the shallow water by the Palæolithic hunters and there became "bogged." Whatever hypothesis may be accepted, there is no evidence of any greater flood or inundation than would often occur under the severe climatic conditions which prevailed during the long period which intervened between the formation of the higher benches of river drift and that of the mid-terrace, only 25 to 30 feet above the present river, in which the remains of the Mammoth and the extinct Quaternary mammalia are more frequently met with under similar conditions. Nor does there appear to be any more reason for ascribing the extinction of the great Quaternary pachyderms to a sudden catastrophe or cataclysm than there is for the extinction of some other Pleistocene forms, such as the Great Irish Deer; while the difficulty involved in this hypothesis is still further increased by the fact that other animals, such as the Reindeer and Musk-sheep of northern habit, as well as southern forms like the Hippopotamus, were not utterly destroyed with their contemporaries by the same cause, but merely migrated to regions more suited to them, as the climatic and other conditions of this country changed.

REVIEWS.

I.—Introductory Text Book of Geology. By David Page, LL.D., F.G.S. Revised and in great part rewritten by Charles Lapworth, LL.D., F.G.S. Twelfth and enlarged edition. 8vo. pp. 309. (London and Edinburgh, Blackwood & Sons, 1888.)

THE publishers of this work are fortunate in having secured Prof. Lapworth's services in bringing out a new edition of it. While careful to retain the arrangement of the original, and whatever was valuable of its matter, the editor has been bold enough to sweep away all that is cumbrous or obsolete, and sufficiently painstaking to rewrite whole chapters in order to bring them abreast of modern geological thought. The result is that he has produced a book which from its simplicity and clearness will be useful for schools, while the introduction of specific names, the careful attention paid to the derivation and meaning of terms, the alternative tables and fresh points of view brought into the "Recapitulations," the real glimpse (not a mere catalogue) of foreign strata, and the new classification of animals and plants, will restore it to its place as an examination text-book. But beyond and above this, the sections on Petrological geology, on the older Palæozoic or Proterozoic rocks, and last but far from least, those on the Igneous and Metamorphic rocks, are well worthy the attention of specialists in these lines of research. That the improvements are wide-spread as well as concentrated we see from the fact that this edition contains more than 70 additional pages and 50 new illustrations. Many of the old artificial-looking sections are replaced by real ones (like the effective drawing of rock strikes in p. 62 and the map and sections on p. 63) and some of the

old fossils are removed and their places taken by others of more value in the present state of science. Professor Nicholson has lent some of the beautiful drawings from his Palæontology, such as *Mosasaurus*, *Dicynodon*, *Hesperornis*, and *Odontopteryx* (whose *artificial* teeth, as a lady student once called them, are well shown), and some of the older pictures like the rather *blasé Pterygotus* of p. 186 look poor beside these modern rivals.

In the short sketch of the objects and scope of geology enough elementary knowledge is imparted to enable the student to follow the succeeding chapter on dynamical agencies modifying the earth's crust; but a great deal of space is saved in this section to be used later on more purely geological matters, the author rightly thinking that much of this will have been taught as Physiography; we may illustrate the thoroughness and conciseness of this part by a single sentence on the formation and maintenance of waterfalls. "Where a hard stratum rests upon one of a softer nature, erosion is arrested above and behind, while it goes on unchecked in front and below." The Petrological division is almost too brief, but we notice some good illustrations and oblique and inosculating (loop) faults are defined.

The Historical Geology of the work is not only thorough, but exceedingly interesting, for the author has the faculty of grasping the general facies of a system and presenting it to his readers as a whole, so that he not only gives type sections and descriptions of the fauna and flora, but in a few graphic touches notes their variations in our own limited area and over the rest of the world. In order to this he does not fetter himself by any single literal plan, but moulds his plan to his subject (this is seen in other chapters), and so presents some systems differently from others. The Archæan chapter is an interesting one, and the author's views may be gleaned from this passage:—"As most of the foliated Archæan rocks occur in areas of regional metamorphism, it may be regarded as tolerably certain that they owe their schistose characters to the same agency, and that we are not dealing in a series of such foliated rocks with rock systems, but with petrological complexes." There is a curious passage on page 150, and one can imagine that the author felt a little tempted to add to his list the Dimetian, Arvonian, Lewisian, and Monian systems with their synonymous localities. It is, of course, needless to say that the hand of the master is clearly traceable through the Cambrian, Silurian, and Ordovician sections, and in the latter he has again raised the Shropshire standard for comparison. The palæontology of each system is gone into in detail, repeated stress being laid on the introduction, modification, and extinction of species; its volcanic energy is described, and space is generally found for an account of the economics and scenery of the rocks and of the phases of Physical Geography to which each is due. Liberal space is allotted to the Carboniferous system, which is used as an illustration of the method of working out a system of rocks in its entirety. But we have not time to deal with each system in detail; the advantages of the method of treatment, the amount of matter introduced, its

reliability, and the attractive manner of its setting forth, will be best appreciated by the readers and students for whom the book is meant. We have purposely delayed to speak of the chapters on Igneous and Metamorphic rocks, as these chapters will be the ones to attract most attention. Both are treated from the point of view of the structural geologist, but one who is well acquainted with the minuter and microscopic characters of the rocks he speaks of. The classification of Igneous rocks adopted has a chemical and mineralogical basis, the minuter subdivisions being effected by differences in origin and texture. A notable passage suggests, "It is far more probable, however, that they (granitic bosses) are really laccolites or intrusive sheets upon a gigantic scale, the plane of intrusion and separation, instead of being confined to a single bedding-plane, crossing the bedding of the rocks of the district more or less irregularly and obliquely."

FIG. 53.

FIG. 54.

FIG. 55.

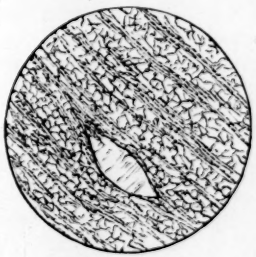


FIG. 56.

Figures illustrating the structures of the Schistose Rocks.

Figs. 53, 54. Macro-structures. Fig. 53. *Flaser gneiss* (*Flaser structure*), natural size. Fig. 54. *Augen-granulite* (*Augen structure*), natural size.

Figs. 55, 56. Micro-structures. Fig. 55. *Mylonite* (*Mylonitic structure*), highly magnified. Fig. 56. *Mica schist* (*Granulitic structure*), highly magnified.

The metamorphic chapter derives great interest from the Survey paper read at the Geological Society a month ago, in which all Prof. Lapworth's conclusions in the Highlands were confirmed. The terms

Hydro-, Pyro-, and Dynamo-Metamorphism are used; the first stages of their action producing altered, but the higher stages metamorphic rocks. Schists are defined as foliated, crystalline rocks, in which the "folia are not in parallel sheets but thin lenticular plates, each plate thickening in the middle," etc. We have next descriptions of *Augen structure, flaser structure* (formed of lenticles or ellipsoidal patches or *phacoids* in a fine base), *granulitic* and *mylonitic* structures, the latter being defined as "Compact slaty-looking rocks, composed of material ground to powder, or rock flour, between the great moving masses in the over-faults of that region, like corn between a pair of millstones." The author takes the responsibility of such of these terms as are due to him, and whatever may be the fate of the terms, the origin of the structures as made out in the Highlands seems to be almost undisputed. By Messrs. Blackwood's kindness we are enabled to reproduce the figures which accompany these descriptions.

Then follows an account of the two main sets of opinions on the origin of these rocks, leading to a description of the Highland section. The picture of this is almost an exact copy of Murchison's, teaching us that to the mere drawing of sections must now be added the skilled interpretation of them. We then have a highly condensed, but very valuable account of the *Deformation Theory of Metamorphism* which we print in full:—

"Founded upon the conclusions drawn from all these discoveries, a new theory of the cause of the association and of the varied petrological characters of the rocks in a district of regional metamorphism is being gradually developed at the present time—a theory most closely related to the original suggestions of Darwin, Scrope, and Sharpe. According to these new views, the rocks in such a district do not necessarily belong to any one distinctive geological period, but may be of various geological ages, owing their present association to the effects of lateral pressure, which has more or less obscured the evidences of their original relationships. Some metamorphic areas may possibly be wholly Archæan; others may be composed of patches originally either Archæan, post-Archæan, plutonic, sedimentary, or volcanic. The present structures of the rocks in various parts of such an area may be either original or secondary, according to the mode or degree of the local metamorphism to which they have been subjected. The granites, gabbros, etc., in such a region are unaltered plutonic rocks; the quartzites, crystalline limestones, and the like, are probably sediments only partly altered. The gneissoid rocks may be either Archæan or post-Archæan plutonic rocks, or felspathic sediments foliated by pressure, intrusion, veining, and the like. The schists may be either metamorphosed sediments, retaining locally their original bedding (where altered by pyrometamorphism and the like), in dynamo-metamorphic rocks showing only secondary structures, but which may have been originally either gneissic, plutonic, or sedimentary rocks, but whose ingredients have been more or less completely rearranged both structurally and mineralogically. In fine, a metamorphic area is a *petrological complex whose altered rocks have a common foliation.* The *strike of foliation* in such a district is

related to the *general strike of the sheets* of sedimentary or crystalline rocks which formed its main masses at the time of its final folding and shearing; the *dip of foliation* is simply the *local direction of shear,—i.e.* is related to the direction in which the mass to which it belonged was giving way. Like cleavage, it may locally coincide with the original bedding; but it normally crosses the bedding at an angle, and *traverses aqueous and igneous rocks* alike. The planes of schistosity are those planes along which the rocks yielded to the lateral pressure or torsion, and these *yielding planes* may be of *all grades of importance*, from the great overfaults, along which solid masses of enormous extent were thrust forward, in some cases for scores of miles, down to the minutest planes separating the microscopic folia of the slaty schists. These planes cut the rock up into lenticular patches or '*phacoids*,' which, like the yielding planes themselves, are of all gradations of size—from the mountain masses riding out along the great overfolds and overfaults, down to the 'eyes' of the 'augen' schists. The *mechanical effects* wrought by the shearing and deformation of the phacoids show of necessity a corresponding gradation, the conditions at one extreme giving rise to coarse *rock-breccias*; in medium cases to *flaser structures* and foliation; at the other extreme to the compact, stringy *mylonite*, in which the original material has been torn and ground to rock-dust. Parallel with these mechanical changes, but not necessarily accompanying them, we note a series of *chemical changes* of rising grades of importance—a larger and larger portion of the rock undergoing deformation becoming recrystallized, until finally, it may all become transformed into foliated crystalline rock. *The maximum of mechanical effects* seem to have been wrought where the rock yielded to the excessive pressure and torsion mainly along certain *definite planes* (shear planes or gliding planes) or *areas* within the mass; *the maximum chemical effects* where the deforming stresses affected *all the particles* of the *mass* alike, the rock yielding or *flowing* in the manner of a plastic or liquid body. In some minor areas the results effected by dynamo-metamorphism possibly approximate to those wrought by pyro-metamorphism, and we may have what has been called *stratification foliation*. In general, however, the foliated rocks have been sheared, and the primary structures have all been more or less obliterated. But, as a metamorphic region may be subjected to successive earth-movements acting at different times, and from different directions, we occasionally find a newer and more or less incomplete foliation crossing an older foliation, or the rocks may show traces of a foliation of a still earlier date: the successive foliation planes being in different stages of development, preservation, or obliteration."

So much has been done in so little space that it seems greedy to ask for more; still, in the next edition we hope the author may be able to supplant the rest of the old work which he has left; to give us a few more figures of type sections, a little more space to the dates and function of earth-movements, and even perhaps also to the physical geography of the different periods. It seems unnecessary to put into words what it is quite certain all readers will think of

this book; but among the expressions of opinion one will be frequent, that it has those qualities which we always recognize in a man of power—strength and firmness combined with a rare modesty.

II.—List of the Fossil Faunas of Sweden. Edited by the Palæontological Department of the Swedish State Museum (Natural History). I. Cambrian and Lower Silurian. 8vo. 24 pp. III. Mesozoic. 20 pp. (Stockholm, 1888, Printed for the Museum by P. A. Norstedt & Söner.)

THE Authorities of the Swedish State Museum intend to publish a list of the fossils (excepting the plants) occurring in the various geological formations of Sweden, and two parts have just been issued. The first of these has been prepared by Prof. G. Lindström, and contains the names of species from the different subdivisions of the Cambrian and Lower Silurian (= Ordovician) in that country. The Cambrian is divided into the following zones, the fossils in each being separately enumerated:—1, Oldest Sandstone Beds, the Eophyton and Fucoid Sandstones; 2, *Paradoxides* Beds, including therein the zones of, (*a*) *Olenellus Kjerulfi*; (*b*) *Paradoxides Œlandicus*; (*c*) *P. Tessini*; (*d*) *P. Davidis*; (*e*) *P. Forchhammeri*; (*f*) *Agnostus lævigatus*; 3, *Olenus* Schists, and 4, *Dictyonema* Slate. The Lower Silurian comprises, 1, *Ceratopyge* Limestone; 2, Lower Graptolite Schists; 3, Orthoceratite Limestone; 4, Middle Graptolite Schists; 5, *Chasmops* Limestone; 6, *Trinucleus* Schists; 7, Brachiopod Schists; 8, Upper Graptolite Schists; and 9, *Leptæna* Limestone. From the Cambrian strata 141 species are enumerated, and 627 from the Lower Silurian, thus making a total of 768 species. Of these no fewer than 365, or nearly one-half, are Trilobites, next in abundance are Graptolites with 146 species, followed by the Brachiopoda with 89 species, and the Cephalopoda with 50 species.

Prof. Lindström remarks that not a single species is recorded as common to the Cambrian and Lower Silurian formations in Sweden, but the latter contains 19 species which recur in the Upper Silurian.

Part II., containing a List of the Upper Silurian Fauna, will be issued in the Autumn; Part III., which has been prepared by Prof. Bernhard Lundgren, records the Mesozoic Fauna. Of the lower portions of the Mesozoic series only the Rhætic and Liassic strata are developed in Sweden, and in these there seems to be but a scanty fauna, for not more than 24 species are enumerated from the former, and 129 from the latter group. There is then a wide gap in the middle portion of the Mesozoic series, until reaching the higher members of the Cretaceous strata, which are richly fossiliferous, the list containing 456 species, mainly from the zones of *Actinocamax mammillatus* and of *Belemnitella mucronata*.

The value of these Lists, prepared as they have been by such well-qualified authorities, will be recognized by all palæontologists, and we hope that the other parts will be successfully completed.

III.—On the Morphology and Origin of the Ichthyopterygia.[1]

By Dr. Georg Baur, Yale College Museum.

THE present paper is one of the results of Dr. Baur's recent tour in Europe, during which he was enabled to examine the Fossil Vertebrata in most of the principal Museums of the Continent and England. The various known characters of the Ichthyopterygian skeleton are reviewed and compared especially with the existing *Sphenodon*; and the conclusion is arrived at, that these Mesozoic marine reptiles bear the same relation to certain ancestral terrestrial Rhynchocephalia, that is apparently borne by the living Cetacea to early ungulate Mammalia. The skull is only comparable with that of the Rhynchocephalia (especially *Sphenodon*) and the Lacertilia. The only real difference is that, as in the Cetacea, the facial portion has been very much elongated. "The general structure of the skull resembles that of the Dolphins: in its *morphology*, it is a copy of the *Sphenodon* skull." Most of the accepted interpretations of the cranial bones are adopted, but a correction is offered in regard to the large bone forming the postero-external boundary of the supratemporal fossa. This is determined to be the supratemporal element of the Lacertilia, and in *Sphenodon* is said to be united with the squamosal; the bone in *Ichthyosaurus* has been termed mastoid by Owen, and squamosal by Seeley and Cope. Between this element, the postfrontal, postorbital, quadratojugal, and quadrate, is articulated the true squamosal, named prosquamosal by Owen, and supraquadrate by Seeley.

After the detailed comparisons, Dr. Baur proceeds to discuss the morphology of the Ichthyosaurian paddle. The most primitive example known is that of *Ichthyosaurus cornalianus*, Bassani, from the Trias of Besano, Italy, which is placed in a new genus, *Mixosaurus*. The radius and ulna are elongated bones, with a considerable intervening space. The paddle of *Baptanodon* or *Sauranodon* is regarded as the most specialized form, and the bone termed by Marsh "intermedium" is interpreted as ulna, while the so-called "ulna" is held as probably representing the pisiforme. The oldest Ichthyopterygia had few phalanges and not more than five digits; later, through the adaptation to the water, the number of phalanges increased, and more digits appeared, chiefly by division of the former, but sometimes by new formation on the ulna side. An interesting analogous case is noted in the manus of a Manatee, in which Dr. Gadow has observed an exceptional increase of the phalanges beyond the normal Mammalian to the number of three.

In conclusion, Dr. Baur proposes the following classification of the Ichthyopterygia:—

Group A. Radius and ulna elongated, separated by a space in the middle. Teeth of two forms, but not so numerous as in the Ichthyosauridæ. Small animals. Triassic.

Family, *Mixosauridæ*, Baur. Genus, *Mixosaurus*, Baur.

Group B. Radius and ulna short bones, touching each other. Teeth well developed and numerous.

[1] *American Naturalist*, 1887, pp. 837-840.

Family, *Ichthyosauridæ*, Bonaparte. Genus, *Ichthyosaurus*, Koenig. Also undefined genera.

Group C. Radius, ulna, and a third bone articulating with the humerus. Teeth rudimentary or absent.

Family, *Baptanodontidæ*, Marsh. Genus, *Baptanodon*, Marsh.

A. S. W.

IV.—"Geology for All." By J. Logan Lobley, F.G.S. (London, Roper & Drowley, 1888.)

"GEOLOGY FOR ALL" is a very attractive title, and we wish that such a work may succeed, for no little credit would attach to the man who could enable the general public to master the alphabet of geology. Outside a limited circle even the well-educated continue in a complete fog as to things which are simple in themselves, and ought to be understanded of the people without difficulty. How far the book in question fulfils this want is a point on which opinions may differ. It is dedicated to the memory of Prof. Morris, and a very good likeness of that best of all geological teachers faces the title-page. Not the least valuable part of this little work consists of the Preface and Introduction, which are full of inducements to pursue the study of geology. When we come to the dry bones of the subject, then a text-book is a text-book, whether it be long or short. On the whole, the author places before his readers a considerable amount of matter of a useful kind within the space allotted to him, though he makes a slip here and there. As, for instance, at page 41, where he is rash enough to give a formula for orthoclase which would yield less than 24 per cent. of silica in a mineral containing over 64 per cent. He is especially strong in dealing with physical features, and his great experience in connection with geological excursions renders this part of his subject comparatively easy to him. We sincerely trust that his ability and enthusiasm may gain many converts to the good cause.

W. H. H.

V.—Free Public Libraries, their Organization, Uses, and Management. By T. Greenwood, F.R.G.S. pp. 320, Illustrated. (Simpkin, Marshall & Co., 1887.)

THIS, though nominally only a fresh issue, is in fact a new edition of the volume which first appeared in 1886. It is printed in a handier form, has undergone revision, and the subject-matter has been re-arranged.

The work "does not seek to be a book of instruction to those in charge of Free Libraries," but is intended to further the extension of the Free Library movement and to aid those who are seeking to secure the adoption of the Libraries' Act in their district by furnishing advice how to initiate and how to carry out the undertaking.

A chapter is devoted to "Museums and Art Galleries,"—and another to "Science and Art"—"in connection with Free Libraries;" but though "Commercial Museums" and "Technical Education" have each their paragraphs, minerals and geological collections have

only an accidental allusion in one case—when the Ipswich Museum and Library are spoken of. Surely some knowledge of Geology, using that term in its widest sense, is both of educational value and technical importance in every district, to say nothing of its extreme usefulness in mining and agricultural centres, and we trust that Mr. Greenwood will in future editions be able to say something in favour of the study of that science which next to chemistry has the greatest influence over the affairs of our every-day life, and thus supply what, to us, seems the one omission in his admirable volume.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 9, 1888.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read :—

1. "The Stockdale Shales." By J. E. Marr, Esq., M.A., Sec.G.S., and Prof. H. A. Nicholson, M.D., D.Sc., F.G.S.

The Stockdale Shales extend in an E.N.E.–W.S.W. direction across the main part of the Lake District, parallel with the underlying Coniston Limestone Series and the overlying Coniston Flags, with both of which they are conformable. They also occur in the neighbourhood of Appleby, and in the Sedbergh district. They are divisible into a lower group of black and dark grey and blue Graptolite-bearing shales, interstratified with hard bluish-grey mudstones containing Trilobites and other organisms, and an upper group of pale greenish-grey shales, with thin bands of dark Graptolitic shales. The lower group (Skelgill Beds) are well seen in the stream which runs past Skelgill Farm, and enters Windermere near Low Wood; while the upper group (Browgill Beds) occurs fully developed in the Long Sleddale Valley, and its beds are very fossiliferous in Browgill.

The authors divide these shales into a series of fossil-zones in the following order :—

- Stockdale Shales
  - Browgill Beds
    - Upper
      - *Bb* 2
      - *Bb* 1
    - Lower
      - *Ba* 2 zone of *Monograptus crispus*.
      - *Ba* 1 ,, ,, *turriculatus*.
  - Skelgill Beds
    - Upper
      - *Ac* 5 ,, *Rastrites maximus*.
      - *Ac* 4 ,, *Acidaspis erinaceus*.
      - *Ac* 3 ,, *Monograptus spinigerus*.
      - *Ac* 2 ,, *Ampyx alonicnsis*.
      - *Ac* 1 *Monograptus Clingani* band.
    - Middle
      - *Ab* 6 Barren band.
      - *Ab* 5 zone of *Monograptus convolutus*.
      - *Ab* 4 ,, *Phacops glaber*.
      - *Ab* 3 ,, *Monograptus argenteus*.
      - *Ab* 2 ,, *Encrinurus punctatus*.
      - *Ab* 1 ,, *Monograptus fimbriatus*.
    - Lower
      - *Aa* 2 ,, *Dimorphograptus confertus*.
      - *Aa* 1 ,, *Diplograptus acuminatus* and *Atrypa flexuosa*.

Of these zones, the lowest varies, occurring as a thin Limestone

in Skelgill, with *Atrypa flexuosa*, n.sp., and as Graptolitic shale at Browgill with *Diplograptus acuminatus*, Nich. The others appear to run persistently across the district, with the exception of the zone of *Rastrites maximus*, which has only been discovered in the Sedbergh area. The thicknesses, lithological characters, and fossil contents of these zones were considered, and comparisons made between these beds and the corresponding deposits of other areas. The whole group attains a thickness of from 250 to 400 feet, of which the Skelgill beds usually make up about one quarter.

The authors correlate the Graptolite-zones with those of the Birkhill and Bala groups of Professor Lapworth as follows:—

Lake District.		South of Scotland.
Zone of *Monograptus crispus*	=	Zone of *M. exiguus*.
,, ,, *turriculatus*		Not separated.
,, *Rastrites maximus*.....	=	Zone of *R. maximus*.
,, *Monograptus spinigerus* / *Monograptus Clingani* band	=	,, *Monograptus spinigerus*.
Not represented?		,, *Petalograptus cometa*.
Zone of *Monograptus convolutus*.. / ,, ,, *argenteus*.. / ,, ,, *fimbriatus*.	=	,, *M. gregarius*.
,, *Dimorphograptus confertus*	=	,, *Diplograptus vesiculosus*.
,, *Diplograptus acuminatus*...	=	,, *D. acuminatus*.

The zones of *M. convolutus*, *M. argenteus*, and *M. fimbriatus* contain abundance of *M. gregarius*, and the zone of *Dimorphograptus confertus* also contains *Diplograptus vesiculosus* in considerable numbers.

The beds were also compared with the corresponding beds in Sweden, Bohemia, Bavaria, etc., and the fossils other than Graptolites were shown to occur elsewhere in strata of Llandovery-Tarannon age, from which it was concluded that the Stockdale Shales occupy that horizon.

A fault occurs everywhere between the Middle and Lower Skelgill Beds, except perhaps in the Sedbergh district; but it does not seem to cut out a great thickness of rock, and the authors gave reasons for supposing that it was produced by one set of beds sliding over the other along a plane of stratification.

The beds are found to thicken out in an easterly direction, and the possibility of the existence of land in that direction was suggested.

The authors directed attention to the importance of the Graptolitoidea as a means of advancing the comparative study of the stratified deposits of Lower Palæozoic age.

A description was given of the following new species and varieties:— *Phacops elegans*, Boeck & Sars, var. *glaber*, *Cheirurus bimucronatus*, Murch., var. *acanthodes*, *Cheirurus moroides*, *Acidaspis erinaceus*, *Harpes judex*, *H. angustus*, *Ampyx aloniensis*, *Proëtus brachypygus*, and *Atrypa flexuosa*.

2. "On the Eruptive Rocks in the Neighbourhood of Sarn, Caernarvonshire." By Alfred Harker, M.A., F.G.S.

The rocks in question occupy an area about $5\frac{3}{4}$ miles long from north to south and $2\frac{1}{4}$ miles broad near the south-western extremity of Caernarvonshire. They were described by the author under the following heads:—

(i.) Granite occupying the northern and north-western part of

the district. The ordinary type is a fairly normal biotite-granite; but a variety at Meillionydd shows an exceptional structure, the biotite moulding the other constituents in ophitic fashion. The granites are intrusive in the Arenig shales.

(ii.) Gabbro, diorite, etc., in two small patches only. The rock, originally a gabbro, passes into diorite, the diallage becoming amphibolized, and the iron-ores disappearing with the production of granular sphene. Near a bounding-fault this hornblendic rock becomes locally schistose and gneissic.

(iii.) Diabase, in the centre, forming the mass of Mynydd-y-Rhiw, and occurring in dykes and sheets near Sarn.

(iv.) Hornblende-diabase showing various relations between the augite and hornblende. Besides the conversion of the former mineral to the latter, a closely similar hornblende has grown as an original border to augite-nuclei. The "secondary-enlargement" of hornblende-crystals is also exhibited.

(v.) Hornblende-picrite in several varieties, forming stratiform banks to a thickness of 250 feet, and surmounted by hornblende-diabase. The two rocks seem to be in close relation to one another, and to have been injected as laccolites between the Upper Arenig strata near Penarfynydd and Rhiw.

(vi.) Dolerite-dykes cutting all the other rocks, and probably Post-Carboniferous and Pre-Permian.

With the exception of the last, all these rocks were referred, on such evidence as is available, to the Bala age.

II.—May 23, 1888.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Spheroid-bearing Granite of Mullaghderg, Co. Donegal." By Frederick H. Hatch, Ph.D., F.G.S. Communicated with the permission of the Director-General of the Geological Survey.

This paper deals with a remarkable variety of granite which may be compared with the well-known orbicular diorite or Napoleonite of Corsica. According to Mr. J. R. Kilroe, of the Geological Survey of Ireland, who first discovered this interesting rock, the concretionary balls occur in close juxtaposition in a mass of granite of 5 or 6 cubic yards in size. They have not been found in any other portion of the granite area.

The author first gave a detailed description of the microscopic structure of the normal granite. It is a coarse-grained rock, composed essentially of quartz, orthoclase, microcline, oligoclase, greenish hornblende and black mica. Sphene is an accessory constituent. Since it contains no white mica, the rock belongs to that subdivision of granite which has been termed *granitite*. A description of the spheroidal bodies was then given. The balls are somewhat flattened, the greatest diameter being, in one case, 4 inches, the smallest 3. Each ball consists of two distinct parts, a pinkish central portion (the *nucleus*) and a dark-coloured peripheral or zonal portion (the *shell*). The nucleus consists of an irregular granitic aggregate of oligoclase felspar with a little interstitial quartz. The peripheral

shell is composed chiefly of oligoclase, but also contains abundant included plates of biotite, and over 12 % of magnetic iron-ore. It is to the presence of the last-mentioned mineral that the zonal portion owes its dark colour. By means of a Sonstadt's solution the oligoclase was isolated and analyzed with the following results :—

SiO_2	=	60·99
Al_2O_3	=	25·56
CaO	=	4·88
Na_2O	=	7·73 [1]
Loss on ignition	=	·84
		100·00

Sp. Gr. = 2·649.

This is the composition of an oligoclase of the formula Ab_3An.

The felspar of the zonal portion is disposed radially, the iron-ore radially and concentrically, while the mica appears to obey no fixed law of arrangement.

A synopsis of the literature concerning the occurrence of similar concretionary bodies in granite was then given, the following authors being referred to:—Leopold v. Buch, Gustav Rose, Allnaud, Charpentier, Jokély, von Andrian, Zirkel, G. W. Hawes, M. de Kronstschoff, J. A. Phillips, vom Rath, Fouqué, Halst, Brögger, and Bäckström.

The conclusion the author arrived at from a consideration of the subject was, that concretionary bodies occurring in granite, may, according to the mode of arrangement of their constituents, be divided into three classes, viz. :—

1. The *concretionary patches* of Phillips.
2. The *granospherites* of Vogelsang.
3. The *belonospherites* of Vogelsang.

The spheroids from Mullaghderg belong to the last-mentioned class. They must be regarded as concretions formed, during the consolidation of the granite magma, by a process of zonal and radial crystallization around an earlier-formed nucleus.

2. "On the Skeleton of a Sauropterygian from the Oxford Clay, near Bedford." By R. Lydekker, Esq., B.A., F.G.S.

A description was given of a considerable portion of the skeleton of a Sauropterygian from the Oxford Clay of Kempston, consisting of several upper teeth, most of the mandible (of which the symphysial region is entire), a considerable number of vertebræ mainly from the "pectoral" and dorsal regions, the greater portion of the two pelvic, and fragments of the pectoral limbs, and a considerable proportion of the pectoral and pelvic girdles. These remains were referred to *Plesiosaurus philarchus*, Seeley, and the various parts described in detail.

The author discussed the advisability of retaining the forms described by various generic names by Professor Seeley, under the name of *Plesiosaurus*, and stated his intention of employing the latter term in its widest sense for the present. With this definition, the form under consideration was shown to present characters inter-

[1] By difference.

mediate between those of *Plesiosaurus* and *Pliosaurus*, but was retained provisionally in the former genus. Although a direct link in the chain connecting the two genera, *P. philarchus* was not regarded as an ancestor of *Pliosaurus*, since teeth undistinguishable from those of the latter genus occur in the Coralline Oolite.

Finally it was concluded that the evidence brought forward was sufficient to render necessary the abolition of the name Pliosauridæ, and the inclusion of *Plesiosaurus* and *Pliosaurus* in a single family.

3. "On the Eozoic and Palæozoic Rocks of the Atlantic Coast of Canada in comparison with those of Western Europe and the Interior of America." By Sir J. W. Dawson, LL.D., F.R.S., F.G.S.

The author referred to the fact that since 1845 he had contributed to the Proceedings of the Geological Society a number of papers on the geology of the eastern maritime provinces of Canada, and it seemed useful now to sum up the geology of the older formations and make such corrections and comparisons as seemed warranted by the new facts obtained by himself, and by other observers of whom mention is made in the paper.

With reference to the Laurentian, he maintained its claim to be regarded as a regularly stratified system probably divisible into two or three series, and characterized in its middle or upper portion by the accumulation of organic limestone, carbonaceous beds, and iron-ores on a vast scale. He also mentioned the almost universal prevalence in the northern hemisphere of the great plications of the crust which terminated this period, and which necessarily separate it from all succeeding deposits. He next detailed its special development on the coast of the Atlantic, and the similarity of this with that found in Great Britain and elsewhere in the west of Europe.

The Huronian he defined as a littoral series of deposits skirting the shores of the old Laurentian uplifts, and referred to some rocks which may be regarded as more oceanic equivalents. Its characters in Newfoundland, Cape Breton, and New Brunswick were referred to, and compared with the Pebidian, etc., in England. The questions as to an Upper Member of the Huronian or an intermediate series, the Basal Cambrian of Matthew in New Brunswick, were discussed.

The very complete series of Cambrian rocks now recognized on the coast-region of Canada was noticed, in connexion with its equivalency in details to the Cambrian of Britain and of Scandinavia, and the peculiar geographical conditions implied in the absence of the Lower Cambrian over a large area of interior America.

In the Ordovician age a marginal and submarginal area existed on the east coast of America. The former is represented largely by bedded igneous rocks, the latter by the remarkable series named by Logan the Quebec Group, which was noticed in detail in connexion with its equivalents further west, and also in Europe.

The Silurian, Devonian, and Carboniferous were then treated of, and detailed evidence shown as to their conformity to the types of Western Europe rather than to those of America.

In conclusion, it was pointed out that though the great systems of formations can be recognized throughout the Northern Hemisphere,

their divisions must differ in the maritime and inland regions, and that hard and fast lines should not be drawn at the confines of systems, nor widely different formations of the same age reduced to an arbitrary uniformity of classification not sanctioned by nature. It was also inferred that the evidence pointed to a permanent continuance of the Atlantic basin, though with great changes of its boundaries, and to a remarkable parallelism of the formations deposited on its eastern and western sides.

4. "On a Hornblende-biotite Rock from Dusky Sound, New Zealand." By Captain F. W. Hutton, F.G.S.

The rock is of eruptive origin, and is associated with Archæan schists and gneisses. It is compact, crystalline, of a dark-green colour, and sp. gr. 3·00—3·07. It is composed of two minerals in nearly equal proportions, one of which, a black mica, has the two optic axes nearly coinciding. The other mineral is of a pale bluish-green colour, and moderately dichroic; it shows an aggregate polarization of rather coarse grains, with here and there distinct crystals of considerable size. Often one side of a crystal shows a single twin, while the other side is polysynthetic. The optical characters are those of the monoclinic system, and further investigation proves these crystals to be hornblende. The mineral which shows aggregate polarization is either crushed hornblende or some altered form of it.

CORRESPONDENCE.

THE CORRELATION OF MIDLAND GLACIAL DEPOSITS WITH THOSE OF LINCOLNSHIRE.

Sir,—It is certainly very desirable that the Glacial Deposits should be correlated with one another, but I do not think any reliable results will be obtained by comparing the descriptions and conclusions which have been published by Mr. Deeley and myself. We have necessarily looked at the beds from different points of view, and I had hoped that Mr. Deeley would have made himself personally acquainted with the tract which lies between the areas we have respectively studied before suggesting anything in the way of correlation.

He thinks that his classification into Older, Middle and Newer Pleistocene might be adopted for Lincolnshire, though the only "Older Pleistocene" deposit known to him in that county is the quartzose sand of Gelston. He suggests, however, that some of the clays classed by me as Newer Glacial may really be older than the Chalky Boulder Clay, and he apparently finds great difficulty in accepting the occurrence of such Newer Glacial Beds at elevations approaching 400 feet. I will only reply that there are many places where he may walk from the eastern plain to the top of the Wold over a continuous sheet of the same kind of Boulder Clay; but when Mr. Deeley can record any facts which seem to support his idea, I shall be quite ready to discuss them.

As regards the Gelston Sand, I must point out that this is an outlying patch, and there is no local evidence to show whether it is older

or newer than the Boulder-clay east of Grantham. Mr. Deeley regards it as older because the material is similar to that of his older Pleistocene sands; he may be right, but neither I nor my colleagues have found any deposits elsewhere in Lincolnshire which could be regarded as distinct from, and older than, the great chalky Boulder-clay.

The only locality where any great mass of Glacial gravel exists is around Benniworth, near Donnington, and this will be described in the forthcoming memoir on Sheet 83 of the Geological Survey Map. There, if anywhere, will Mr. Deeley find the analogue of his Older Pleistocene; but I very much doubt whether clays containing Pennine detritus ever extended so far to the east. If any Older Pleistocene deposits existed in East Lincolnshire, I should expect them to be rather of the Cromer than of the Pennine type.

With regard to the marine origin of the Newer Glacial clays, I would call attention to the remarkable deposits near Kirmington in North Lincolnshire, where laminated loams and sands containing perfect shells are associated with Boulder-clay of the Hessle type in such a way as to lead to the conclusion that they all belong to one group. These beds were carefully studied by Mr. C. Reid, and it is to be hoped that a description of them may soon be published.

The most surprising statement in Mr. Deeley's article is that many geologists regard the glaciated surfaces beneath the Drift of Lancashire as caused by large icebergs grating along the bottom of a sea about 1200 feet deep! He must have strangely misunderstood the views of those who believe the striæ to have been caused by sea-ice, and surely a little consideration will enable him to see that every single striated surface might have been glaciated in shallow water during the progress of a gradual submergence. I certainly never heard of any one who supposed that no such action occurred till the water was 1200 feet deep.

Mr. Deeley has done good work in the Midlands; let me recommend him to take his note-book into Lincolnshire, and when he publishes his observations, to keep his facts rigidly apart from his theories.

SHIRLEY, SOUTHAMPTON. A. J. JUKES-BROWNE.

DISCOVERY OF LOWER CARBONIFEROUS BEDS IN UPPER EGYPT.

SIR,—The discovery of Lower Carboniferous beds in the wild region between the Nile and the Gulf of Suez adds a new feature of interest to the Geology of Egypt. The announcement is contained in a memoir by Dr. Schweinfurth, of Cairo, of which he has been kind enough to forward me a copy containing the result of an exploration by himself and M. Walther, of Jena, into the valley of the Arabah, and communicated to the Egyptian Institute.[1] At first I was somewhat startled by the title and the early pages of the memoir, as the members of the Expedition of the Palestine Exploration Society (1883—4) had failed to notice any Carboniferous beds in the Wâdi Arabah, at the head of the Gulf of Akabah, until we lighted upon

[1] "Sur une récente Exploration Géologique de l'Ouadi Arabah," Le Caire, 1888.

them at Lebrusch, on the flanks of the Moabite hills above the shore of the Dead Sea. I supposed, therefore, that Dr. Schweinfurth had found what we had failed to notice. But, on reading further, the matter was set at rest. It is somewhat unfortunate, and tending to confusion, that there are two Arabah valleys, one in the eastern part of upper Egypt, opening out on the Gulf of Suez, and the other connecting the Gulf of Akabah with the Dead Sea and Jordan Valley. The former is that referred to by the African explorer, and is of special importance as helping to connect the geology of the Upper Nile Valley with that of Arabia Petræa. Dr. Schweinfurth recognizes the identity of the beds he describes with those of the Wadi Nasb in the Sinaitic Peninsula, where limestone containing fossils of Carboniferous Limestone age, first discovered by Mr. Bauerman, are interposed between crystalline rocks and sandstones and other strata of Cretaceous age. These beds were afterwards examined by Col. Sir Charles Wilson and by the Members of the Expedition of 1883—84, and the fossils brought home by them were determined by Prof. Sollas.[1] Of this identification of the beds of the Wadis Nasb and Arabah there can be no question, as the genera of the fossils are in most cases identical, and the species characteristically Carboniferous.

The following is a section of the beds in the escarpment of the southern flank of the plateau of north Galala, descending to the bottom of the Wadi Arabah, in Upper Egypt, as given by Dr. Schweinfurth :—

Summit of Escarpment; 1400 m. above the sea.

300 m.—Terraines Tertiaires du Parisien.
200 m.—Terraines Tertiaires Londinien (?).
200 m.—Banks of débris covering Cretaceous-beds of Stages *Up. and Lr. Senonien.*
50 m.—Argillaceous and Marly ochreous Limestone and sandy beds with *Ammonites. Senonien inferieur.*
250 m.—Escarpment of red Nubian Sandstone. (*Terrains Crétacés d'incertains étages*).

(Geat Geological hiatus.)

2 m.—Dark Sandstones with silicified wood (*Araucarioxylon*). *Lower Carboniferous.*
60 m.—Solid and soft Sandstones and Marls, with fragments of Crinoids, and *Spirigera.*
1 m.—Bed of hard blue Limestone—with *Crinoids, Productus, Spirifer,* etc.—(Carboniferous Limestone).
40 m.—Marls and Sandstone partly fossiliferous.
Lower Carboniferous.

(Details of beds below this not given.)

Geological Survey Office, Dublin, 23 *May,* 1888. E. H.

THE ATMOSPHERE OF THE COAL PERIOD.

Sir,—From the silence of your reviewer, I presume that he is unable to verify the assertion so often made that experiments had proved the improbability of plants living in an atmosphere containing an excess of carbonic acid. As I before remarked, very few definite experiments had been made besides the one I have quoted in my work. I might, however, have referred to those made by

[1] "Physical Geology of Arabia Petræa and Palestine," Mem. Palestine Exploration Fund, p. 48.

Daubeny in his Reports to the British Association 1847—1850, "On the Influence of Carbonic Acid Gas on the Health of Plants, especially to those allied to two Fossil Remains found in the Coal-formation." These, although wanting in definite measures and not embracing the whole field of inquiry, are of great value so far as they go, as they confirm at all events the possibility of the original suggestion of Brongniart with respect to the condition of the atmosphere during the Coal Period.

Daubeny showed that *Lycopodium* continued during five weeks in perfect health in an atmosphere containing 5 per cent. of carbonic acid, though species of *Adiantum* appeared less thriving than the corresponding plants not so treated, but that 20 per cent. of carbonic acid proved injurious in two or three days. He also found that Frogs and Newts did not appear to suffer in an atmosphere containing 5 per cent. of the gas. This, however, is a proportion quite excessive and perfectly unnecessary for the object in view, and is therefore beyond the mark. Nevertheless, Daubeny came to the conclusion that the general tenor of his experiments justified him "in inferring that there is nothing in the organization of those plants and animals of the present day which appear most nearly allied to such as were in existence during the Carboniferous epoch, or even somewhat subsequent to that period, militating against the probability, that a larger amount of carbonic acid may have been present in the atmosphere and diffused throughout the waters of the sea and rivers, than is found either in the one or the other at the present time; nor is there anything to prevent us from imagining that the absorption of carbon by vegetables and the consequent rapidity of their growth may, at least within certain limits, have borne some proportion to the greater amount of carbonic acid assumed to have been present at earlier periods in the history of our globe."

JOSEPH PRESTWICH.

THE GEOLOGY OF MYNYDD MAWR.

SIR,—I have been much interested in Mr. Harker's description of the rocks of Mynydd Mawr and the Nantlle Valley. His observations on the cleavage structure round the intrusion point it out as a great "eye," whose main axis runs parallel to the cleavage of the district. Last year, while endeavouring to work out the structural relations of the mass, I paid considerable attention to all the junctions, especially those along the S.E. flank. These are everywhere of an obviously intrusive character, the "quartz-porphyry" frequently transgressing upon the bedding of the slates. The main difficulty about the junction to me was that in some places the slates dipped under the intrusive mass, while in others they dipped off it. But I found one section in which the bedding rose vertically, and then bent outwards at an angle of 45°, the porphyry in the upper part resting on the slate. Probably this relation of the two rocks frequently exists round the hill, the lines of rock flowing (if we may use the term) round the intrusion not only in a horizontal but also in a vertical direction.

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